

Lives And Works Of Civil And Military Engineers Of America (1871)



Charles B. Stuart



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Lives And Works Of Civil And Military Engineers Of America

Charles B. Stuart

LIVES AND WORKS

OF

Civil and Military Engineers

OF

America.

BY

CHARLES B. STUART, C. E.,

AUTHOR OF "NAVAL DRY DOCKS OF THE UNITED STATES," "NAVAL AND MAIL STEAMERS OF THE UNITED STATES;" LATE ENGINEER-IN-CHIEF OF THE U. S. NAVY, AND STATE ENGINEER AND SURVEYOR OF NEW YORK, ETC., ETC.



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The Great International RAILWAY SUSPENSION BRIDGE Over the Niagara River.

A Full View of the Falls.

Connecting The United States & Canada. The New York Central & Great Western Rail-Roads.
Length of Track above the Water 250 feet
Total Length of Wires 4000 Miles
Cost \$1,000,000. J. A. ROBERTSON, Engineer

Length of Span from centre of Towers 823 feet.
Four Wire Cables 30 inches in Diameter.
In Each Cable 3660 No 9 Wires.

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* Engraved for this work, 1859.

PREFACE.

To commemorate the lives of American citizens eminent in the profession of engineering, and who are no less illustrious for their virtues and patriotism, this work is designed.

The object of the author has been to briefly portray the lives of pioneer American Engineers, and to collect some of the reminiscences of the earlier works of engineering of the country, with which their names are identified.

The description of the works alluded to in this volume is necessarily general in its character, and embraces less of detail than it would were it intended for professional reading alone.

Few circumstances have contributed so much to promote the commerce and great prosperity of the States as our system of internal improvements, for which we are largely indebted to the skill, foresight, and integrity of the Civil Engineer, and there is no profession to whom, in this country, less public justice has been accorded.

In the arrangement of the several subjects, reference is had to their succession in time, commencing with those

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who were most conspicuously identified with our first public improvements, and noting some of the most prominent men and works at various periods, down to recent dates.

Brevity, and fidelity of statement, has been his aim rather than literary style or eloquence of description.

In the limit of time embraced he is conscious of having included but a few only of those whose lives and labors deserve to be more fitly and fully recorded than he is able to do. But the aid and encouragement that has been tendered in behalf of the undertaking by the most prominent Engineers in every State of the Union, in the collection, not only of information embodied in the following pages, but of Engineers for whose biographies he is collecting material, encourages the hope that, as intervals of time can be had from active professional engagements, other volumes will succeed this, until some slight degree of justice shall have been done to other deserving men of the profession.

In executing the design, on all occasions of doubt and uncertainty resort has been made to the best sources for information to which access could be had, and no diligence or research has been neglected to make the work complete. If errors are found to exist, the author would feel grateful to those who might direct his attention to them, that corrections may be made in future editions.

In a work of this kind much, from its nature, must be compilation, and to those of whose previous labors the

author has availed himself he gratefully acknowledges his obligations.

The author desires also to acknowledge the gratification he has derived from the many encouraging letters he has received, and the assistance which the numerous voluntary contributions of valuable information and important data have afforded him in the preparation of this work.

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APPENDIX.

A. DESCRIPTION OF THE UNION CANAL, PENNSYLVANIA, 1830.
B. FIRST EIGHT-WHEEL LOCOMOTIVE.

Pages 327—331.

MAJOR ANDREW ELLICOTT,

SURVEYOR-GENERAL OF THE UNITED STATES.

THE subject of this sketch devoted a long life to the service of his country, and illustrated in an eminent degree the valuable aid intelligence and learning can render in the settlement and civilization of a new country.

Andrew Ellicott, the paternal ancestor of the Ellicott family in America, was born in Wales, and emigrated to America in seventeen hundred and thirty-one, bringing with him one son, Andrew. His wife remained in England, and through untoward circumstances never joined her husband, although an affectionate correspondence was kept up between them. According to family tradition, "she was a woman of great goodness, intelligence, and beauty ; worthy of her husband, who was a man of high character in every respect, one indeed of nature's noblemen." The following ejaculatory lines were written by her on the departure of her husband and son for America.

"Through rocks and sands,
And enemies' hands,
And perils of the deep,
Father and son,
From Collosston,
The Lord preserve and keep.—1731."

Like a true Christian, this good woman, in these prayerful lines, forgot herself in her anxiety for her husband and child, and makes historical record of the date and place of their departure.

On their arrival in America they proceeded to Pennsylvania, where the father purchased one hundred and fifty acres of land, in Bucks County, near Doylestown, for his future residence.

Joseph Ellicott, father of the subject of this biography, and a son of Andrew Ellicott the younger, who came from Wales in seventeen hundred and thirty-one, was a man of considerable local notoriety, for his mathematical knowledge and mechanical skill. In seventeen hundred and sixty-six he visited England, and while there purchased many valuable mathematical instruments, and on his return home he invented a most interesting and curious machine, *a musical clock*, now in the possession of Mrs. Catherine Evans, of Albany, N. Y. In the construction of this wonderful piece of mechanism he was assisted by his son Andrew, then about fifteen years old, who, young as he was, had become quite expert in the manufacture of astronomical instruments. This clock is of the ordinary size, and is enclosed in a substantial mahogany case. It has four faces. One indicates the hour, the day of the month, and the year; and one hand traverses around the face, by successive movements, once in a hundred years. Another face exhibits an orrery, and displays the motions of the heavenly bodies. A third face exhibits a combination of musical bells, arranged to play twenty-four different tunes, one for each hour of the day. The

remaining face exposes a view of the whole internal machinery.

There is much in the mental constitution of families. The whole history of the Ellicotts in this country, from the early emigrant Andrew, down to a recent date, is a record of useful practical inventions. They came from an inventive stock in the old country, for it is observed that, from the year sixteen hundred, every generation of the family has been distinguished in some of its members by mathematical knowledge, or mechanical skill.

Joseph Ellicott, with his brothers, purchased (about seventeen hundred and seventy) two tracts of land on the Patapsco river, and soon after erected merchant flour mills, that were afterwards widely known as "Ellicott's Upper Mills," and "Ellicott's Lower Mills." They had previously built a mill at Jones' Falls, near Baltimore, the ruins of which were visible a few years since. They also established an iron foundry at Elkridge Landing, then a flourishing place, and, at that time, the rival of Baltimore.

The Ellicotts introduced on this Continent the use of Plaster of Paris as a fertilizer, and the first experiments with it were made at Ellicott's mills. They projected and promoted the Baltimore and Fredericksburgh turnpike, and one of their number, Jonathan Ellicott, designed and constructed the bridge across the Monocacy river, esteemed at the time a piece of extraordinary architecture. They were the chief instigators of the Cumberland Road, a turnpike of much importance before the construction of railroads.

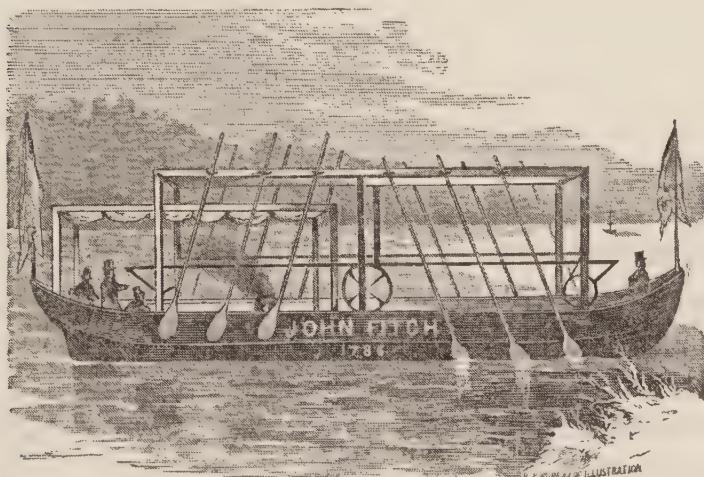
To the Ellicotts we are indebted for the use of stencil plates, which they substituted for the use of the old style of branding with hot irons. The first rolling mill and blast furnace erected in Baltimore was by John Ellicott, who is said to have been the first person in this country who utilized the waste heat arising from the gases evolved in the blast furnace as an agent for the economical generation of steam. They also introduced in milling the "elevator," the "conveyer," and the "hopper-boy." About the year seventeen hundred and eighty-six, Oliver Evans published the first edition of the "Millwright and Miller's Guide," a book which is yet considered a standard authority, in which he frankly asserts that the practical and essential parts of the work were received from Thomas Ellicott.

About the year seventeen hundred and eighty-nine John Ellicott, a cousin of Andrew, was engaged in experiments in steam machinery for the propulsion of boats, a subject which was attracting much attention from the more speculative of the mechanical engineers of the time. He was very enthusiastic in the opinion that "not only steam-boats would be navigated through the water, but that the time was approaching when roads would be so constructed and adapted to machinery that *steam cars would roll their rapid wheels from city to city.*"

It has been claimed by some that John Ellicott invented the *first steamboat** that was constructed in this

* It was about the year seventeen hundred and eighty-nine that the first steamboat that ever moved upon the waters of America floated in triumph along the canal at Ellicott's Mills—the steamboat of John Ellicott.—*From the Howard District Press, published at Ellicott's Mills eighteen hundred and forty-seven.*

country. But this assumption must be received with a liberal allowance to a local pride of being successful claimants to an invention that has produced such results in ocean and river navigation ; for it is now well authenticated that the first boat successfully propelled by steam power in America, was constructed and tried by John Fitch, at Philadelphia, August twenty-second, seventeen hundred and eighty-seven, in the presence of nearly all the members of the Convention to form the Constitution of the United States.



FIRST STEAMBOAT, 1786.

This fact is asserted by the certificates of Dr. Johnson, of Virginia, David Rittenhouse, John Ewing, and Andrew Ellicott,* and others, two years previous to the

* From the well known force of steam, I was one of the first of those who encouraged Mr. Fitch to reduce his theory of a steamboat to practice, in which he has succeeded far beyond my expectations. I am now fully of the opinion that steamboats may be made to answer valuable purposes in facilitating the internal navigation of the United States, and that Mr. Fitch has great merit in applying a

time stated in the paper referred to, that John Ellicott's steamboat was supposed to have had a triumphant success.

His experiments resulted in a disastrous accident, by which he lost his right arm. While secretly experimenting alone in the night, the safety-valve of his boiler became obstructed, and a violent explosion was the result.

Andrew Ellicott, eldest son of Joseph and Judith Ellicott, was born in Bucks County, Pennsylvania, January twenty-fourth, seventeen hundred and fifty-four. He remained in Pennsylvania until December, seventeen hundred and seventy-four, when he married, and removed with his father's family to the Patapsco, and settled at the place since known as "Ellicott's Upper Mills," in Maryland. He was associated with his father for a number of years in watch and clock making, and assisted him in constructing the celebrated musical clock, already alluded to. His attainments in science soon drew public attention to him, and from the Revolution to the day of his death he was employed in the fulfilment of trusts conferred by the General or State Governments.

Though belonging to the Society of Friends, he commanded a battalion of Maryland militia in the Revolution, with the rank of Major. In seventeen hundred and eighty-four he was employed on behalf of the State of

steam engine to so valuable a purpose, and entitled to every encouragement from his country and countrymen.

Philadelphia, December thirteenth, seventeen hundred and eighty-seven.

ANDREW ELICOTT.

Virginia in fixing the boundary line between that State and Pennsylvania. He had previously been commissioned by Congress to assist in the division of the new States, and settlement of boundary lines. About this time the University of Williamsburgh, Virginia, conferred upon him the degree of Master of Arts.

In his Journal he says, "the sickly condition of my family fixed my resolution of leasing my property, and removing to Baltimore." This change of residence he effected in April, seventeen hundred and eighty-five. In this year he was appointed by the Governor of Pennsylvania, with David Rittenhouse and Andrew Porter, a commissioner to locate the western boundary of that State.

August twenty-fifth, seventeen hundred and eighty-five, he writes: "The boundary line between the States of Virginia and Pennsylvania was completed on the twenty-third day of this month. It makes a most beautiful appearance from the hills, being between sixty and seventy miles due north, and cut very wide through the woods, and perfectly straight. The Indians appear very peaceful, and I do not apprehend there can be any danger within the compass of our business from them. My principal companion is Mr. Rittenhouse, who is a gentleman I daily find new reasons for admiring."

In December, seventeen hundred and eighty-five, he visited Philadelphia, and spent some time with Mr. Rittenhouse, and also visited Dr. Franklin, with whom he maintained the most intimate relations. In April, seventeen hundred and eighty-six, he again visited that city to

meet Governor Clinton and Mr. De Witt, as a State Commissioner, but upon what business, other than that it was public, he does not state. He says of Governor Clinton, "he appeared to be a thoughtful old gentleman, and Mr. De Witt a man twenty-seven or eight years of age." Mr. Ellicott was commissioned in June, seventeen hundred and eighty-six, by the Supreme Executive Council of Pennsylvania, to run the northern boundary line of that State. While running this line, in seventeen hundred and eighty-six and seven, he visited Lake Erie, and with prophetic judgment writes: "The United States of America have more natural advantages than any other Government or power in the world, and if they judiciously turn to their own account those advantages which they have, from the nature of the country, they must become both rich and powerful."

While a resident of Baltimore, Major Ellicott represented that city in the Legislature of Maryland with ability and credit. He also, during this portion of his life, devoted himself much to astronomy.

Major Ellicott did not long reside in Baltimore, but about seventeen hundred and eighty-nine moved to Philadelphia, and was there called the "Geographer of the United States."

In seventeen hundred and eighty-eight the Supreme Council of Pennsylvania directed that a survey of the islands in the rivers Alleghany and Ohio, within the bounds of the State, should be surveyed, and to Major Ellicott this duty was intrusted.*

* Colonial Records, vol. xiv., p. 615.

In seventeen hundred and eighty-nine, Phelps & Gorham, who had purchased the Massachusetts pre-emption claim to Western New York, were desirous of fixing the western boundary of that State, to ascertain if it did not include the present town of Erie, in Pennsylvania; the belief being quite general that it did—so much so, that the State of Pennsylvania, in the winter of seventeen hundred and eighty-eight and nine, made propositions to purchase it, in order to give that State a front for commercial purposes on Lake Erie. If the western boundary of New York did not include it, then it belonged to the United States.

For the purpose of ascertaining the facts in the case, the United States Government sent Andrew Ellicott in seventeen hundred and eighty-nine, for the purpose of running and establishing this line. Frederick Saxton was associated with him on behalf of Phelps & Gorham. Joseph and Benjamin Ellicott were also of the party. As the line was to run due south of the west end of Lake Ontario, it was necessary to go into the province of Upper Canada to ascertain, by accurate measurement and observation, the west end of that lake; but, in proceeding to that point, they were arrested in their progress by the military authorities of Fort George, now Niagara, until permission to proceed was given by the Governor-General at Quebec. A messenger, for aid and instruction, was despatched to President Washington, at Philadelphia. The President represented to the Governor of the Canadas the object of the expedition, and immediately received the desired permission. Arriving at their destination, there

was some hesitation in determining whether the line should commence at the western extremity of Burlington Bay (at the head of which the city of Hamilton now stands), or at the peninsula separating the bay from Lake Ontario. It was at length fixed at the peninsula ; and on the completion of the survey, by first running some distance south, and then offsetting around the east end of Lake Erie, the line was found to pass some twenty miles east of Presque Isle, now Erie. The line thus established forms the western boundary of the State of New York, and is the eastern line of the tract known as the "Presque Isle triangle," which was afterwards purchased by Pennsylvania from the United States, and is now a part of that State.

This survey was completed, October tenth, seventeen hundred and ninety, as stated in a letter by Major Ellicott, dated Presque Isle Fort, October eleventh, in this year : "Yesterday I completed the business, after much hardship, trouble and difficulty."

His very valuable service, in this highly important and responsible survey, seems to have been duly appreciated by the President, and other public officers ; for he writes, in the same year : "General Washington has treated me with attention. The Speaker of Congress, and the Governor of the State, have constantly extended to me most flattering courtesies."

While making the traverse of the Canadian side of the Niagara river, he first saw the Falls of Niagara ; and with Joseph and Benjamin Ellicott, as assistants, made the *first actual measurement of the entire length of the river, and of the*

falls and rapids from Lake Erie to Lake Ontario. Major Ellicott, in making his report of the survey of the boundary line, mentions these measurements of the river, which have ever since been accepted as correct.*

	MILES.	FALLS.
From Lake Erie to the head of the Rapids.....	20	15 ft.
From the Rapids to " " Falls.....	1½	51 "
The Great Fall	162 "
From the Falls to Lewiston.....	7	104 "
From Lewiston to Lake Ontario.....	7	2 "
Total.....	35½	334 ft.

In seventeen hundred and ninety Major Ellicott was employed by the United States Government to survey and lay out the District of Columbia and the city of Washington. For many years he enjoyed the cordial friendship of Washington, Jefferson, and other leading men of the country, who highly appreciated his scientific abilities and unexceptionable private character.

In seventeen hundred and ninety, Phelps & Gorham sold to Robert Morris a portion of their lands lying on the easterly side of their purchase, and adjoining what was termed the "Livingston Indian Lease Company's tract." Livingston having illegally leased the land from the Indians, the State of New York declared the lease void. The line, as run by the surveyor of the Company, was west of what afterwards became the village of Geneva. But

* Ellicott's report to the President of the United States, seventeen hundred and ninety.

Robert Morris, being dissatisfied with it, employed Andrew Ellicott to determine the true line. Major Ellicott, assisted by his brother Benjamin, and by Augustus Porter, run the line, and found it to be as far east of the village of Geneva as Mr. Jenkins, the surveyor of the Lease Company, made it west of that place. The difference between the two lines made eighty-four thousand acres in favor of Robert Morris, of what is now the most valuable and beautiful portion of Western New York. The care taken by Major Ellicott to insure correctness in this survey—it being made with the best instruments then in use—caused it ever after to be acquiesced in.

In April, seventeen hundred and ninety-three, Governor Mifflin, of Pennsylvania, appointed Andrew Ellicott, William Irvine, and John Wilkins, Jr., commissioners, to view and lay out a road from Reading to Presque Isle, in that State.

On the fourth of May, seventeen hundred and ninety-six, Andrew Ellicott was appointed by President Washington commissioner to fix the boundary line between the United States and the Spanish possessions. He set out on this important mission on the sixteenth of September, seventeen hundred and ninety-six, by the way of the Ohio and Mississippi rivers, accompanied by his eldest son, and a detachment of United States troops. The Spanish Governor having possession of Natchez, in Mississippi, delayed him in the execution of his mission for one year. After running the line he returned by sea, and arrived at his home in Lancaster, Pennsylvania, in May, eighteen hundred.

After his return home from Florida, by Governor McKean he was appointed Secretary of the Land Office of Pennsylvania. He continued in office until removed by Governor Snyder, in eighteen hundred and eight, and then retired to private life. September first, eighteen hundred and eight, he was elected to a membership of the National Institute of Paris.

As an officer of the Philosophical Society of Philadelphia, he frequently filled the chair so often occupied by Franklin, Rittenhouse, and Jefferson, at the meetings of that learned Association. He was on intimate terms with the most learned men of his time. In his Journal he mentions a very flattering visit from Dr. Rush, and also from Dr. Priestly, who, he says, "is considered one of the greatest men now alive. He looks very well, and is remarkably lively for a person of his great age."

Major Ellicott's claims, for expenses incurred in the service of the General Government, and part of his salary, seem to have been grossly neglected. In March, eighteen hundred and one, the office of Surveyor-General of the United States was tendered to him. In referring to the proffered office, in a letter addressed to Mr. Wilkinson, of Washington, April eighth, eighteen hundred and one, he says: "No objection to the office of Surveyor-General, if it could be kept at the seat of Government, which would certainly be the proper place, and which will become obvious when the public lands, from Lake Michigan to our southern boundary, are offered for sale. I have not means at hand to journey to Washington, and am still

feeling ill effects from exposure for eleven months in the woods of Florida. I am distressed because my pay has been withheld. I have been obliged to sell my valuable library, and dispose of my Theodolite to Major Jonathan Williams, to procure money for market to-morrow ; ruined, and for nothing but faithful services ; never used a farthing of public money ; never lost a single observation by absence or inattention ; and never, when out on public business, was caught in bed by the sun ; and if any person living can produce a solitary instance to the contrary, he shall be entitled to everything I claim from the public. The Spanish Commissioners divided about twenty-six thousand dollars, besides their pay, and have been complimented by the Court of Madrid."

Notwithstanding the unjust and inexcusable neglect of the Government to meet his just claim for important services rendered, and expenses incurred, his patriotism and love of country continued unabated ; and his faith in its importance amongst the nations of the earth, and the glorious future of the Union, founded upon a sound and far-seeing judgment, was unbounded.

In a letter to President Jefferson, in eighteen hundred and one, in which he dwells upon the importance of our country being practically, as well as theoretically, independent of the mother country, he remarks : "That Greenwich is 5h. 44", or $76^{\circ} 56' 6''$ east of the city of Washington. I have long been wanting our longitude to be reckoned from *our own capital*, and not from a point within any other nation ; and for this purpose, have calculated an almanac adapted to the meridian of the city of

Washington. We appear yet to be connected with Great Britain by a number of small ligaments, which, though apparently unimportant, are nevertheless a drawback upon the absolute independence which we ought, as a nation, to maintain."

In June, of the same year, Major Ellicott says to Monsieur De Lambre, of France, in a letter accompanying his astronomical and meteorological observations on the southern boundary: "I shall be highly gratified if the observations should merit the attention of the Institute, as they were made by a *self-taught astronomer, and the only practical one now in the United States.*" In reply, he received a very flattering acknowledgment from the learned Professor, for his valuable papers.

In December, eighteen hundred and one, Major Ellicott wrote to President Jefferson (inclosing astronomical observations): "Being now the only native of the United States left, which time has not swept away, who has cultivated practical astronomy for the purpose of rendering it useful to commerce, to the divisions of territories, and the determination of the relative parts of our country, I feel a desire to keep the subject alive, till succeeded by some American whose fortune may put it in his power to be more useful, by enabling him to devote his whole time to the improvement of so important a branch of science."

With the enterprise that has been a distinguishing trait of the people of that State as early as seventeen hundred and eighty, the subject of internal improvements engaged the attention of the General Assembly of Pennsylvania;

and in that year an Act* was passed by this body appointing Commissioners to examine the Delaware, Schuylkill, Susquehanna, and Juniata rivers, and the various streams running into them, and which are capable of being made navigable. Major Ellicott, as one of the Commissioners, made the surveys. He was instructed to "carefully mark such places where, in your opinion, locks or canals are necessary. You will note all falls, obstructions, and all matters and things necessary to form estimates to be laid before the General Assembly, of the expenses of clearing and removing such obstructions to the navigation of said rivers." * * * * *

His report of the results of these surveys was so favorable that soon after a company was chartered for inland improvement and navigation, of which Major Ellicott remarks in his Journal :

"The proposed Improvement Company of Pennsylvania appears to me the most rational and practical scheme that can be devised for effecting those improvements in roads and canals, which the present state of our country so loudly calls for."

Major Ellicott took a most lively interest in every movement that had for its object the improvement of the country. He was painfully conscious that, from causes incident to a new country, we, as a nation, were in a condition of infantile dependence in all matters belonging to the higher branches of education ; he consequently labored with a patriotic zeal, with his distinguished com-

patriots Franklin, Rittenhouse, Rush, and others, to promote the diffusion of philosophical and scientific intelligence throughout the country.

In eighteen hundred and two Andrew Ellicott wrote to Monsieur De Lambre, Secretary of the National Institute of Paris: "In this country I have not a single astronomical correspondent, neither is it a science which has been patronized by either of the States or by the General Government. A science in this country which cannot support itself must perish. The economy of public money is considered as the standard of merit, and supposed to include everything necessary for the honor, dignity, and reputation of a nation. From this circumstance there is not within the United States a single Observatory, nor a single citizen, except myself, who is paying any attention to practical astronomy, and what I do is at my own expense. The President of the United States is both a lover of science and a man of science himself, but he has no power by our Constitution to aid any branch of philosophy, mechanics, or literature, unless it be done at his own cost."

In eighteen hundred and three Major Ellicott wrote and published "The Journal of Andrew Ellicott, late Commissioner on behalf of the United States for determining the boundary line between the United States and the possessions of his Catholic Majesty in America."

For more than forty years and up to the time of his death he was constantly employed in some public capacity; yet he never found it necessary to seek a position. His high character and superior intelligence elevated him without special effort of his own to a leadership in those depart-

ments to which his life was devoted. He had an exalted sense of duty and a well-sustained conception of personal responsibilities. In reply to Mr. Jefferson, acknowledging the appointment of Surveyor-Generalship of the United States, he says: "The proposition I consider as one of the most honorable and flattering incidents of my life, and were my own feelings and inclinations alone concerned I should not hesitate one moment in accepting the place you offer. But as there are some other considerations to be brought into view and duly weighed before I can give a definite answer, I wish the subject to be suspended for a few days." Seven days after, he wrote the President submitting his own proposed arrangements for executing the duties of the office, and remarks, "if they coincide with your ideas upon that subject and come within the meaning of the law, I shall have no objections to the appointment."

In the year eighteen hundred and eleven, Major Ellicott was commissioned to run the northern boundary line of Georgia, and set out, accompanied by his son Joseph, from his home, which was then in Lancaster, Pennsylvania, on the first of July in that year. They embarked at Philadelphia for Charleston, South Carolina, and from thence proceeded to Savannah, and the upper country of Georgia, and after running the line, returned in May, eighteen hundred and twelve.

Andrew Ellicott was appointed Professor of Mathematics in the Military Academy at West Point, September first, eighteen hundred and thirteen, and immediately removed to that place with his family. In May, eighteen hundred and seventeen, he proceeded to Montreal, by

order of the Government, to make astronomical observations (determining the intersection of the forty-fifth parallel of latitude), to carry into effect some of the articles of the Treaty of Ghent.

During his residence at West Point, he devoted much of his time to astronomy, which was his favorite study. Notwithstanding his other varied talents, he did not possess those adapted to the acquisition of wealth, of which he had excellent opportunities to avail himself, had his genius led in that direction.

He died at West Point, August twenty-eight, eighteen hundred and twenty, in the sixty-seventh year of his age. His wife survived him, and died in the year eighteen hundred and twenty-seven. They had ten children, four of whom were sons; the daughters, and three sons survived their parents.

President Hale, in his memoir of Major David Bates Douglass, the son-in-law of Andrew Ellicott, says: "The memoirs of the late Andrew Ellicott, when written, will form a valuable addition to the history of our country, taking us away from the beaten ground of battle fields, and Senate Chambers, and Cabinets, to the services which science can render in the settlement of a new country in a civilized age."

JAMES GEDDES,

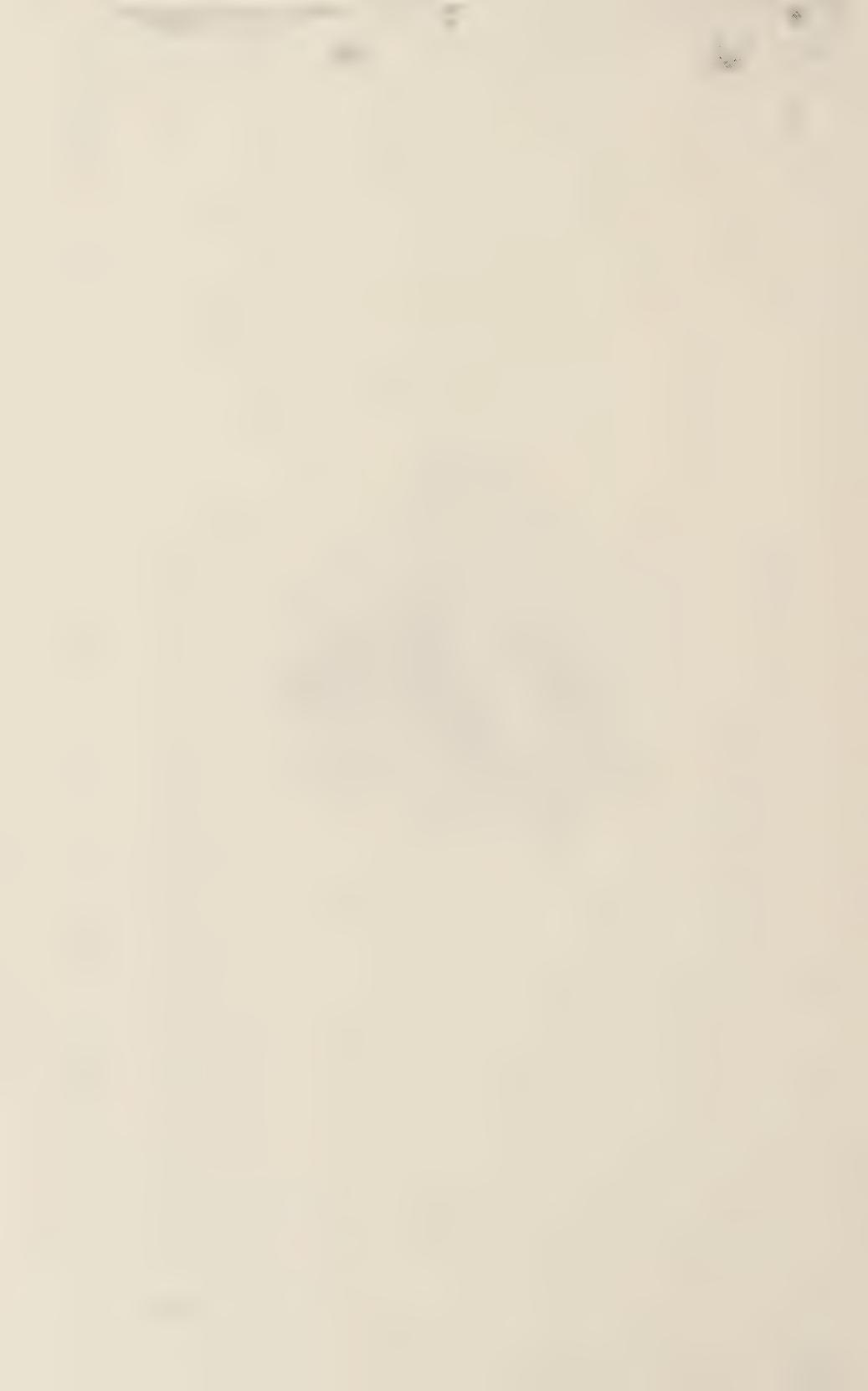
SURVEYOR AND CIVIL ENGINEER.

NEARLY half a century has passed away since the completion of the Erie Canal was celebrated with unusual ceremonies and unbounded demonstrations of joy from the shores of Lake Erie to the harbor of New York. Time has demonstrated that the rejoicings attending the flotilla that started from Lake Erie on the twenty-sixth day of October, eighteen hundred and twenty-five, to mingle the waters of that lake with those of the Atlantic, were fully justified ; and although the great men who took part in that grand celebration were naturally wrought up to the highest enthusiasm, yet they failed to portray the far-reaching effects of that great achievement. In the course of events, other and more rapid modes of transportation have been completed, and diverted public attention from this pioneer improvement, until few are perhaps aware that even now, in the extent and value of its tonnage, *it far exceeds the whole foreign commerce of the United States.*

It has been justly said that “ the authors and builders, the heads who planned and the hands that executed this stupendous work, deserve a perennial monument, and they will have it.” To borrow an expression from the highest



J. C. C. Geddes, Enginner



of all sources, "*The works which they have done, these will bear witness of them.*" Americans can never forget to acknowledge that they have built the longest canal in the world, in the shortest time, with the least experience, for the least money, and to the greatest public benefit.

The Erie Canal has exerted an influence and power that beyond computation excels that of any other investment of money ever made in any nation. Not only States that border on the great lakes owe their prosperity, some of them their existence, to this canal, but the States beyond the great River Mississippi must for ever find their markets through its channel to the Atlantic cities.

To the State of New York is due the glory of this most salutary enterprise. It is an interesting inquiry, how was this single State induced to see the importance, and to bravely attempt the construction, of this long line of artificial navigation? Public opinion was not formed in a day, and the necessary facts upon which to base discussion were not easily obtained at that early period in the history of internal improvements in this country, or in England.

Long before that great and sagacious statesman, De Witt Clinton, whose very name was a tower of strength, had perhaps ever thought of the measure that was destined to crown him with a glory only second to that of Washington, other men had been examining the country, with a view of determining the directions of the water-courses and other physical features of the great plain that stretches from tide-water on the Hudson to Lake Erie, in the hope that nature had interposed no obsta-

cle to a canal, uniting the waters of the lake and the river.

The gathering of facts by patient toil, subject often to ridicule, went on for many years in the centre of the State, before the subject may have been considered as having attracted public attention. The facts thus gathered were the basis of action for De Witt Clinton. He had the sagacity to understand them, and to give them their just consideration.

Abundant evidence exists in public documents that, in all these preliminary labors, Judge Geddes bore an important, if not absolutely indispensable part. "He lived near the centre of the State, and all his interests were connected with the growth and prosperity of the country in which he had made his home, and untiringly he pressed his investigations as to the character of the surface of the country west of the great chain of swamps. Extensive correspondence was resorted to with land agents, surveyors, and other men, who, it was supposed, might be able to give information, and every available map was consulted. He did not rest with this; he formed public opinion, and agitated the subject, until, in eighteen hundred and seven, it had become a theme of so great interest in Onondaga County, that it was the turning point of local politics."*

In the introduction to the natural history of the State of New York: "The merit of first suggesting a direct communication from Lake Erie to the Hudson is given to Gouverneur Morris, qualifying the praise by the fact that

* Hon. George Geddes' Address before the Historical Society of Buffalo, N. Y.

the scheme conceived was that of a canal with a uniform declination, and without locks, from Lake Erie to the Hudson. Morris communicated his project to Simon De Witt, Surveyor-General of the State, in eighteen hundred and three, by whom it was made known to James Geddes in eighteen hundred and four."

The scheme was, by the Surveyor-General, considered "*as a romantic thing, and characteristic of the man,*" and had the idea fallen into no other hands than Morris' and his, it probably had borne no fruit. The suggestion, however, once made to the Land Surveyor of the interior, it began to take form and substance. Jesse Hawley was interested, and his essays signed "Hercules," in the *Genesee Messenger*, continued from October, eighteen hundred and seven, until March, eighteen hundred and eight, brought the public mind into familiarity with the project.

In eighteen hundred and seven, Judge Joshua Foreman, of Onondaga County, and Judge Benjamin Wright, of Oneida County, became enlisted in the cause, and were elected members of the Legislature by the citizens of those counties, with express reference to moving in that body the grand project of a canal; and on the fourth of February, eighteen hundred and eight, legislative action was had, and an appropriation of six hundred dollars was made for the preliminary surveys of the route. These important explorations were intrusted by the Surveyor-General of the State to James Geddes, and executed by him in a manner highly creditable to himself, and satisfactory to the Legislature, over a large area of country, embracing not only the main line of the proposed canal, but,

as stated in the report of Simon De Witt, "other parts of the country were to be explored in order to ascertain which of all practical routes would be most eligible, and this resulted in a report of one almost precisely on the line which, after repeated elaborate and expensive examinations, was finally adopted."

These extensive surveys by Judge Geddes extended from Oneida Lake to Lake Ontario, where the Salmon Creek enters it; another line down the Oswego river to the lake; a line from Lewiston to the navigable waters of the Niagara river, above the Falls; and then from Buffalo east, until the waters flowing into the Seneca river were reached; and that, too, following the best route that exists for a canal; and all this work was accomplished for the small sum of *six hundred and seventy-three dollars!* Did the State ever have so much service performed for so trifling a sum of money before or since?

Governor Seward, in the introduction before quoted, says of this legislative action: "But how little the magnitude of that undertaking was understood, may be inferred from the fact, that the appropriations made by the resolution to defray the expenses of its execution were limited to six hundred dollars. There was no Civil Engineer in the State of New York. James Geddes, land surveyor, who afterwards became one of our most distinguished Civil Engineers, by the force of native genius and application, in mature years," was appointed to make the survey, and reported, "that a canal from Lake Erie to the Hudson was practicable, and could be made without difficulty."

This preliminary survey made De Witt Clinton a Canal man ; a most valuable acquisition to the cause, in view of his great political and legislative influence. In the report of the Commissioners following this exploration, this beautiful sentiment is supposed to have come from the pen of Gouverneur Morris : " Standing on such facts, is it extravagant to believe that New York may look forward to the receipt, at no distant day, of one million dollars nett revenue from this canal ? The life of an individual is short. The time is not distant when those who make this report will have passed away. But no term is fixed to the existence of a State ; and the first wish of a patriot's heart is that his own may be eternal. But whatever limit may have been assigned to the duration of New York by those eternal decrees which established the heavens and the earth, it is hardly to be expected that she will be blotted from the list of political societies before the effects here stated shall have been sensibly felt. And even when, by the flow of that perpetual stream which bears all human institutions away, our Constitution shall be dissolved, and our laws be lost, still the descendants of our children's children will remain. The same mountains will stand, the same rivers flow. New moral combinations will be formed on the old physical foundations, and the extended line of remote posterity, after a lapse of thousands of years, and the ravages of repeated revolutions ; when the records of history shall have been obliterated, and the tongues of tradition have converted the shadowy remembrance of ancient events into childish tales of miracle, this national work shall remain. It shall bear

testimony to the genius, the learning, the industry, and intelligence of the present age."

Judge Geddes, in conjunction with his duties as Judge of the county in which he resided, accepted, in the year eighteen hundred and sixteen, the appointment of Engineer on the Erie Canal, in charge of that portion of the work from Seneca River to within eleven miles of the mouth of the Tonawanda Creek, upon which he continued until eighteen hundred and eighteen, when he was directed to superintend the location of the middle division between Rome and Utica.

During this period he also made a remarkable *test level* between Rome and the east end of Oneida Lake, *embracing nearly one hundred miles of levelling, the difference at the junction in the levels being less than one and a half inches.*

Previous to commencing the surveys for the Erie Canal in eighteen hundred and eight, Judge Geddes had used a spirit level upon one occasion only, and then but for a few hours, and under the following circumstances. A law had been passed directing two hundred and fifty acres of land to be laid out in the Salt Spring reservation, and sold to the highest bidder; the avails to be appropriated for the construction of an east and west road across the reservation. The survey was completed, and Judge Geddes reported a fine water-power on the tract. The Surveyor-General, Simon De Witt, being assured by certain parties opposed to the construction of the contemplated road, that there was no water-power worth improving on the locality designated, he therefore put a

spirit level into his gig and made a journey, as it was deemed in that early day, from Albany to where Syracuse now stands, and, with the assistance of Judge Geddes, levelled along the Onondaga Creek, and found that there was a good water-power. Thus was learned by the Land Surveyor the use of the spirit level, with which in after years he became so proficient.

This level, which is a superior instrument, was used for many years by Judge Geddes in his work on the canals of New York, and in exploring for the Ohio improvements. It is now in the possession of his son, Hon. George Geddes, Civil Engineer, who treasures it in connection with these interesting reminiscences.

In the summer of eighteen hundred and eighteen Judge Geddes was instructed by the Canal Commissioners to repair to the Champlain Canal, under the appointment of Chief Engineer. He commenced the final location of the work in September of that year, and continued in charge of its construction until eighteen hundred and twenty-two, when the State of Ohio applied to Governor Clinton to select a person "to make the necessary surveys for a canal from the Ohio River to Lake Erie." He recommended Judge Geddes as a most competent engineer of location.

He accepted the appointment and performed the duties devolving upon him with marked ability and energy. The district of country embraced by his investigations was, with few exceptions, a complete wilderness; hence the preliminary surveys were exceedingly arduous; yet they

were completed in an almost incredibly short period of time, and his report submitted to the Board, who expressed their approbation in these words :

“ The Commissioners would do injustice to their feelings if they did not avail themselves of this opportunity of bearing testimony to the integrity, ability, and industry with which Judge Geddes has discharged the important duties committed to him. Upwards of nine hundred miles of country have been examined, and the *level of nearly eight hundred miles has been taken with only one instrument, in less than eight months.* His perseverance, and the interest he has taken in effecting objects so important to the State, under all the privations and exposures to which his duties have subjected him, will now and hereafter, when the great work he has commenced shall be completed, be duly appreciated by the people of Ohio.”

He returned to New York in eighteen hundred and twenty-three, and was called to the State of Maine, to survey the route of a canal from Sabago Pond, to the tide waters at Westbrook.

In eighteen hundred and twenty-seven, Judge Geddes entered the service of the General Government, locating the Chesapeake and Ohio Canal. In eighteen hundred and twenty-eight, he was employed by the State of Pennsylvania, upon its canals, and in that year he was also appointed by the United States Government to examine the country in reference to the connection of the Tennessee and Alabama rivers, in the States of Tennessee, Alabama, and Georgia. This appointment he, however,

declined, on account of distance from home, and his advanced age.

James Geddes was born on the twenty-second day of July, seventeen hundred and sixty-three, near Carlisle, in the State of Pennsylvania. His father and mother were both descendants of Scotch families. He studied mathematics under the charge of Mr. Oliver, a man of thorough education. Languages he studied without masters, and became a scholar of the first order. In seventeen hundred and ninety-three, he visited Onondaga County, in the State of New York, and settled at Geddes (named for the Judge) in seventeen hundred and ninety-four ; which place was his residence until his death, August nineteenth, eighteen hundred and thirty-eight, he being a little more than seventy-five years of age, thirty years of which had been devoted to the arduous and responsible duties of his chosen profession, and in the service mostly of his native and adopted States.

He was emphatically a master spirit in pushing forward the early enterprises of his country, but he left no collection of papers by which a compiler might do justice to his memory. He had been solicited to do so, but declined, saying, "I attach no importance to what I have done, having simply performed my duty ; therefore I ask no higher place in the public estimation than should be spontaneously given to me."

When the surveys of the Erie Canal were first commenced, there was nothing on this continent that could be looked at or used by the engineers of the State, for their

instruction, unless the work of the "Inland Lock Navigation Company," at Little Falls, may be considered an exception. Civil engineering, as a profession, had no existence. Books were not published then, as now, from which systematic information could be procured. Attempts were therefore made by the Canal Commissioners of the State to procure the services of Mr. Weston—an eminent English engineer, who had visited this country to direct the construction of the locks at Little Falls—to take charge of the Erie Canal, offering him ten thousand dollars per annum; but his advanced age compelled him to decline; upon which, they were forced to accept the offers made by our own engineers to take the responsibility of executing the work.

The State of New York was fortunate in having among its land surveyors, men who, surmounting every difficulty, achieved with limited capital, not only success, but whose examples of integrity, industry, and perseverance will forever be a standard for the imitation of American engineers.

These men were subjected to various trials, under the rigid system of economy they were compelled to practise, known only to those who were united by their services and professional pride, in the successful accomplishment of an enterprise which had become the great object of their lives. Through difficulties and perplexities, they toiled on, slowly progressing, until at last the work was completed, and fully tested; and they stood triumphant before the country. A strong bond of union continued

through life between these noble and brave-hearted men, who had labored with such devotion and zeal for the public good. As brothers they lived, manifesting for each other sympathy and kindness through all their various engagements ; like brothers they mourned, as, one by one, the links in life's chain were broken.

BENJAMIN WRIGHT,

SURVEYOR AND CIVIL ENGINEER

THE example of Washington, who laid the foundation of his fortune and fame by his early enterprise and industry as a surveyor of new lands, incited many ingenious young men to break away from their quiet homes in the older States and try their fortunes in the promising West. Of this class, and amongst those who by their success have merited a lasting monument to their memory, and to whom a conspicuous place should be given in the history of the country, is the early Chief Engineer of the Erie Canal.

Benjamin Wright was born in the town of Wethersfield, in the State of Connecticut, October tenth, seventeen hundred and seventy. His father, being a farmer of limited means, could only afford his children the advantages of the common schools of the time, during the winter months.

From his childhood Benjamin manifested a deep interest in mathematics, and the studies relating to surveying. At the age of sixteen an opportunity was offered him for following the inclination of his mind, and of extending his knowledge in his favorite studies. He was sent to reside with an uncle of his at Plymouth, in Litchfield County,



Blanch



where he had access to the best books and instruments which could then be obtained by country surveyors. With his growing knowledge of the art of surveying he imbibed the spirit of Western emigration, which was then beginning to move the enterprising and hardy sons of New England toward the fertile valley of the Mohawk, and the fruitful region of the Genesee.

Flattering inducements were held out to young men who were capable of surveying land and preparing title deeds. In those regions of the country, the wilderness was to be explored, towns were to be planted that should grow into cities, and a commanding influence was to be exercised by those who should lead the way in these works of civilization.

Young Wright soon formed the design of trying his fortune in this then remote region, at the first favorable opportunity that should present itself. His spirit was imparted to his father's family, who, with himself, now in his nineteenth year, set off for the settlement at Fort Stanwix (now Rome), Oneida County, State of New York.

Fort Stanwix was then on the western borders of civilization, a small clearing in the midst of a dense and extended forest, remote from other white settlements. The only roads were the dilapidated remains of a military road of the Revolutionary War, the paths of the hunter, the surveyor, and the natives. For a short time he assisted his father and brothers in clearing a field and erecting a log cabin, a kind of domicile with which the most favored of the pioneers were happily content. His knowledge of surveying soon became known amongst the settlers, and

he began to find employment in his favorite pursuit. Through this employment he had access to the maps and drawings of very extensive tracts of land around Fort Stanwix, which originally had been laid out in lots of five hundred acres each. These he subdivided into such smaller lots as the settler purchased, which was rarely more than a half, or a fourth, of the original lot ; thus making a demand for his services as often as a new resident made his location within the settlement. He gave up all his time to his studies, excepting when in the field. He procured from abroad the best books, maps, and instruments, and by patient toil embodied his daily observations in accurate topographical maps. His descriptions, estimates, and surveys became authority in all questions of boundaries.

Between the years seventeen hundred and ninety-two and seventeen hundred and ninety-six, *he laid out into farms five hundred thousand acres* in the counties of Oneida and Oswego. This was a period of great fatigue and hardship. His party, for many months together, would pitch their rude tents in the trackless forest, far from the habitations of civilized men, where wolves and panthers howled about them by night, and the fierce savages surprised them by day. These labors would not seem to have any very important relation to subsequent and more important work ; but had he been impelled by a foresight of future events he could not have been more minute and exact in his topographical surveys than he was, or more careful in preserving his field notes and other information. These he found of great use to himself, while, several years afterwards he was engaged in locating the line of the Erie

Canal. In the midst of his hardy and homeless pursuits he did not forget his early sentiments, and perhaps youthful pledge, and in seventeen hundred and ninety-eight, having laid the foundation for a comfortable competency, he returned to Plymouth and married the daughter of Simeon Waterman, and brought her to his Western home on the Mohawk.

The attachments of a happy home, and the claims of his family, gradually drew him from the field and the forest, and engaged him in other scenes. The wilderness, which he entered in seventeen hundred and eighty-nine, had become a rural district of great agricultural wealth. The surplus products of the soil sought a market, at the distance of one hundred miles, over roads which scarcely deserved the name. In this state of affairs the people became eager for some water passage from Oneida Lake, through Wood Creek, to the Mohawk and the Hudson rivers. In seventeen hundred and ninety-two, the "Western Inland Lock Navigation Company" was formed for this purpose, and William Weston, an engineer from England, was employed to construct the improvements around Little Falls, on the Mohawk, and thence from the river to Wood Creek, at Fort Stanwix. A few years after the completion of these works, it seemed desirable to improve the navigation of Wood Creek, by dams and locks, there being a descent in about six miles, of nearly twenty-four feet, and the navigation very difficult.

At a meeting of the Directors of the Company, General Philip Schuyler being President, the subject was discussed, when a serious difficulty presented itself. Mr.

Weston had returned to England, and it was said he would have to be recalled to make the necessary instrumental examinations—there being no experienced American engineer. To procure Mr. Weston's services would be expensive. The Directors hesitated ; Mr. Huntington asked, "Have you not a levelling instrument?" "Yes ; but we have no one competent to use it." His reply was, "I can use it. There is no mystery about the matter of using a level." General Schuyler raised his head, saying, "That must be so ; I am sure there must be ability enough at home to make these simple examinations, and we need not send to England." Mr. Huntington's reply was, "Put your instrument in my hands, and I will have the work done for you in a satisfactory way. I will not do it myself, but I will find a man who will do it." Immediate assent was given, and he returned to Fort Stanwix with the level. He went to Judge Wright, and said, "I have pledged myself to have a map and profile of Wood Creek made, and you are the man to do it." The Judge assented, took the instrument, and examined carefully its construction, tried an experimental level, starting from a fixed point, after a careful adjustment of the instrument, and ran off half a mile or so, and tested his work by returning to the starting point. He found his work all right. He went on and made the map and profile desired, to the satisfaction and delight of the Directors. *It was Judge Wright's first work as an engineer.*

The Company was so well satisfied with the manner of his executing these duties that the President directed him to make a survey of the creek, from the point

where the improvements ended, down to the Oneida Lake. This he performed in the spring of eighteen hundred and three. Immediately after completing this work on Wood Creek, Mr. Wright received further directions from the President to survey the Mohawk river from Fort Stanwix to Schenectady, about one hundred miles—"taking a regular traverse of the river, its windings, its breadth, the descent of each rapid; the descent between the rapids, the depth in each pool between rapids—at its lowest summer draught—the height of alluvial banks, and all other remarks and observations which he might think useful;" and, as a final duty, to propose his own plan of improving the river in as economical a manner as possible, and one adapted to the circumstances of the Company. This duty was ably concluded in eighteen hundred and three, by recommending a compound of dams, locks, and short canals, to form a slack-water navigation, upon the cheapest possible and useful plan. Unfortunately, the pecuniary affairs of the Company never permitted them to construct any portion of the work contemplated at that time.

In eighteen hundred and eleven, Mr. Wright was employed, by the Canal Commissioners, to make an examination of the north side of the Mohawk river, from Rome to Waterford, on the Hudson. His instructions and report are an appendix to Canal Reports, volume first. In eighteen hundred and twelve, he received directions to examine the country from Seneca Lake to Rome, and from thence on the south side of the Mohawk to Albany. His report, accompanied by maps and profiles, of this examination, was very full and complete.

About this time Mr. Wright became the agent of the land proprietors in whose service he had made the most extensive surveys, and the heirs of those great estates bear uniform testimony to the ability and fidelity with which he fulfilled his trusts. But these agencies did not prevent him from taking an active part in the public affairs of the county in which he lived, being repeatedly elected a member of the State Legislature. During the war of eighteen hundred and twelve, Mr. Wright, who had been appointed County Judge, fulfilled the duties of that office, and continued his agency for the proprietors of new lands. But, when the work of executing the Erie Canal was entered upon in earnest, he withdrew from all other employments, and devoted his whole time and talents to the advancement of that great work.

After the efficient organization of the Canal Board in eighteen hundred and sixteen, there was a division of opinion on the question of sending abroad for a Chief Engineer, but the views of Joseph Ellicott, and others in Western New York, prevailed in favor of intrusting this responsible position to Judge Wright and Judge Geddes. Thus was the novel, and to some minds doubtful experiment made of intrusting this important work to the skill and ability of two country surveyors, both of whom, by a singular combination of circumstances, were self-educated men, and both had risen to the dignity of Judges in the courts of their respective counties.

It is now a matter of history that these two men gradually gained the entire confidence of all parties, and that they richly deserved it ; for, although the work was the

first of its kind in America, of vast extent, and its details spread out into almost infinite variety, yet the industry, forecast, and skill of these engineers, and their wisdom in the selection of their able assistants, were so well applied, that the many enemies of the enterprise made no political capital out of their errors or defects, nor did the State suffer for any want of fidelity and ability in the discharge of their arduous and important duties. They also showed great sagacity in beginning their work in the middle of the line, and working east and west, through the least difficult and costly parts. In this way they conciliated adversaries, and prepared the public mind to meet the vast expense of the works near the Cohoes, and Little Falls, the Genesee river, and the mountain ridge.

At the session of the Legislature of eighteen hundred and sixteen, petitions were presented from all parts of the State, and an able and eloquent memorial from the city of New York, from which the following is taken :

“ A great chain of mountains passes through the United States, and divides them into Eastern and Western America. In various places rivers break through those mountains and are finally discharged into the ocean. To the west there is a collection of inland lakes exceeding, in aggregate extent, some of the most celebrated seas of the Old World. To connect these great sections by inland navigation, to unite our Mediterranean Seas with the ocean, is evidently an object of the first importance to the general prosperity. If a river or natural channel, navigable one hundred and seventy miles, has been productive of such signal benefits, what blessings might not be

expected of it were it extended three hundred miles, through the most fertile country in the universe, and united with the great seas of the West? Great manufacturing establishments will spring up, agriculture will establish its granaries, and commerce its warehouses, in all directions. Villages, towns, and cities will line the banks of the canal, and the shores of the Hudson, from Erie to New York."

This powerful petition made a profound impression upon the Legislature, securing at once the law of April seventeenth, eighteen hundred and sixteen, being the first practicable step towards the prosecution of the project. The whole plan was embraced under this law, and from that day the prosecution of the canals proceeded with a celerity that astonished its projectors, and confounded its opposers.

The first engineers appointed under this law were :

James Geddes, in charge of the western section of Erie Canal.

Benjamin Wright, in charge of the middle section of Erie Canal.

Chas. C. Broadhead, in charge of the eastern section of Erie Canal.

The Commissioners, with two engineers, visited the Middlesex Canal, to obtain practical information, before proceeding with the surveys and estimates for the Erie Canal.

The dimensions of the Erie Canal were fixed by the Commissioners, at Utica, in July, eighteen hundred and seventeen, as follows: Width of canal on bottom twenty-eight feet, at surface forty feet, and depth four feet · the

locks ninety feet in length, and twelve feet wide in the clear. On this basis, the first engineer's estimate of the Erie Canal was made, March, eighteen hundred and eighteen.

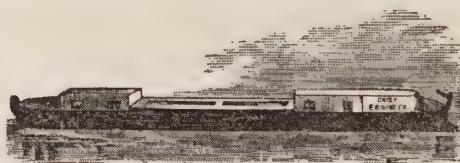
Western section by James Geddes.....	\$1,801,862
Middle, " " Benjamin Wright.....	853,186
Eastern. " " Chas. C. Broadhead...	2,271,690
<hr/>	
Total.....	\$4,926,738

The first expense of the engineering department was submitted April, eighteen hundred and seventeen, and amounted to fourteen thousand four hundred and sixty-two dollars. Total expended for explorations and surveys up to eighteen hundred and seventeen, forty-two thousand nine hundred and fifty-seven dollars. The first contract was dated June twenty-seventh, eighteen hundred and seventeen. The first ground was broken for the canal at Rome, July fourth, eighteen hundred and seventeen. Mr. John Richardson held the plough that opened the furrow in the commencement of the Erie Canal.

The report of the Commissioners, dated January, eighteen hundred and eighteen, gives details of the system adopted for the construction of the canal. That they decided to extend the middle division to Utica, and resolved to let the work in short sections to contractors ; decided on a long summit level. Fifty-eight miles was put under contract during the year eighteen hundred and seventeen, wholly on the summit level. One contract was completed and settled ; the whole labor performed was equal to the completion of fifteen miles. "Three Irish-

men finished three rods of canal, four feet cutting, in five and one-half days. On the fifty-eight miles only one-half mile required puddling."

The middle section was completed October twenty-second, eighteen hundred and nineteen, from Utica to the Seneca river, ninety-four miles. The original engineer's estimate of the cost of this section, extended to Utica, was one million and twenty-one thousand eight hundred and fifty-one dollars. The actual cost was one million one hundred and twenty-five thousand nine hundred and eighty-three dollars, an increase of a little more than ten per cent. This increase was from a change of prism and structures, as stated by the Commissioners. The construction of thirty-five miles in the vicinity of the Cayuga marshes was greatly retarded by sickness, over one thousand laborers being disabled from this cause, between the middle of July and October. Water was let into the long level between Utica and Syracuse with great ceremony.



FIRST CANAL BOAT.

The first boat passed on the Erie Canal from Rome to Utica on the twenty-second day of October. It was dragged by a single horse trotting on the towing path. It was built at Rome (from a design by Canvass White), was sixty-one feet in length, and seven and one-half feet in width, having two rising cabins of fourteen feet each, with a flat deck between them. It was constructed to

carry passengers, and was called the "Chief Engineer," in compliment to Benjamin Wright.

Elkanah Watson, in a book written in eighteen hundred and twenty, describing the ceremony, says: "The President and other members of the Board of Commissioners, attended by many respectable ladies and gentlemen, embarked on the ensuing day at Utica, with a band of music, to return to Rome. The scene was extremely interesting and highly grateful. The embarkation took place amidst the ringing of bells, the roaring of cannon, and the loud acclamations of thousands of exhilarated spectators, male and female, who lined the banks of the new-created river. The sight was truly sublime."

At a meeting of the Canal Commissioners, held at Utica, October, eighteen hundred and nineteen, it was resolved to let sixty-three miles of the western, and twenty-six miles of the eastern section, the latter being from Utica to Little Falls.

The Commissioners, in their report of February, eighteen hundred and twenty, remarked that "the novelty of seeing large boats drawn by horses, upon waters artificially conducted through cultivated fields, forests, and swamps, over ravines, creeks, and morasses, and from one elevation to another, by means of ample, beautiful, and substantial locks, has been eminently exhilarating."

Tolls were first levied on the Erie Canal July first, eighteen hundred and twenty. The unexpected loss of water on the completed middle section settled the question of the necessity of feeding the western section from Lake Erie. David Thomas was employed, with assist-

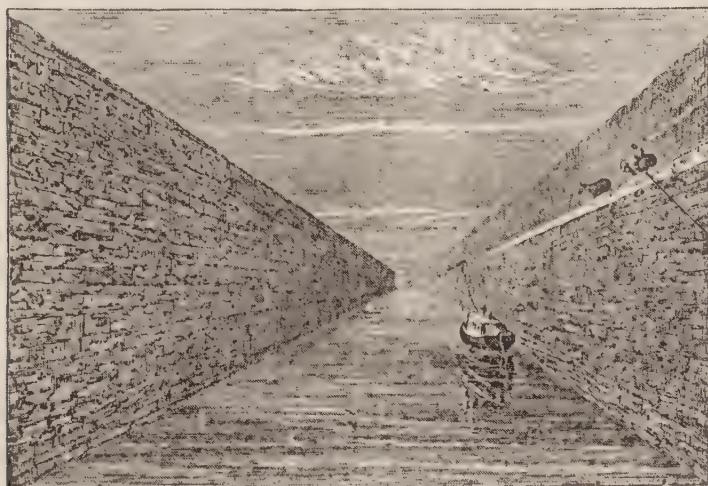
ants, in locating this portion, from May to November, eighteen hundred and twenty. From the Genesee river, easterly, fifty-one miles were under contract, including the whole distance to Montezuma, except nine miles.

The western section, from the Genesee river to the mountain ridge, was let in July of this year, and during the season the whole distance from Tonawanda to Seneca river put under charge of contractors. The line across the Cayuga marshes was located in May, and the work commenced in June, eighteen hundred and twenty-one. The number of workmen engaged was from two hundred to seven hundred. Many of the contractors and men were prostrated by sickness during August of this year.

The canal was completed and navigated from Utica to Little Falls in September, eighteen hundred and twenty-one, and the remaining portion contracted for to the Hudson river, including all structures. A wooden lock was constructed at German Flats, connecting the canal with the Mohawk, thus making an uninterrupted navigation from Schenectady to Cayuga and Seneca Lakes for boats of sixteen tons burthen. Messrs. Wright (principal) and White (acting), engineers, explored the country thoroughly from Little Falls to the Hudson, and pronounced impracticable the route from Schenectady, connecting with the Hudson, back of Albany, and located the line *via* Cohoes and Troy. This location was finally confirmed by Messrs. Wright, Geddes, and White.

Two hundred and twenty miles of the Erie Canal were completed and navigable in the fall of eighteen hundred

and twenty-two. In June of this year, the rock-cutting through the mountain ridge was assumed and performed by the State. Two miles of the unfinished portion, containing two hundred and sixty thousand cubic yards of rock, the earth on top being over twelve feet cutting, requiring the removal of ninety-four thousand four hundred cubic yards of excavation. This deep cut, of more than seven miles in length, is one of the most interesting places on the canal, and presents a striking evidence of human power and enterprise.



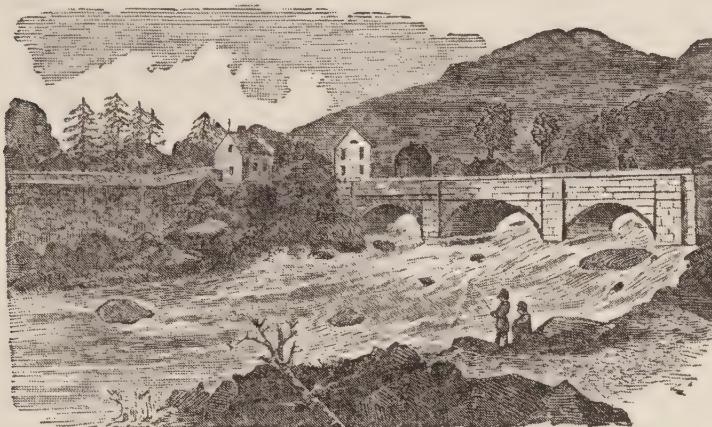
DEEP CUTTING AT LOCKPORT.

On the fourteenth of October, eighteen hundred and twenty-two, the water was first passed through the canal, over the Irondequoit embankment, seventy feet high, supplied from the Genesee river, and produced at once active navigation, before rendered nearly useless for want of an adequate supply of water. Not being able to complete the canal across the Cayuga marshes, a wooden lock

connected it with the Seneca river; so that in May, eighteen hundred and twenty-two, tolls began to be collected upon the western section. The middle section was navigable from April to December this year, including the eastern section from Utica to Little Falls.

"Next to the mountain ridge, the construction of the canal at the Little Falls was the most formidable labor executed. During some mighty convulsions of nature the waters of the West at a former period evidently tore for themselves a passage through what previously had been a barrier of mountain granite. The hills rise on either side to a height of nearly five hundred feet, and at one point the cragged promontories approximate very near. Through this chasm the Mohawk tumbles over a rocky bed and falls, in the distance of half a mile, to the depth of forty feet. The old canal of the 'Inland Lock Navigation Company' was constructed on the north side of the rapids, which affords a far more favorable route. The Erie Canal runs upon the south side, the bed of which was excavated in the solid rock. The view is exceedingly wild and picturesque. Above, the rocks impend in rugged and fearful grandeur; while beneath, the foaming torrent of the Mohawk dashes from rock to rock until it leaps into a basin of great depth, and then steals tranquilly through the rich vale, extending to the falls of the Cohoes. The village stands upon the north side, and is connected with the canal by a stupendous aqueduct, thrown over the river by means of three arches, viz.: an elliptical one of seventy feet, embracing the whole stream in an ordinary state of its waters, with one on each side, of fifty feet

span, elevating the surface of the canal thirty feet above that of the river.”*



VIEW OF THE AQUEDUCT AT LITTLE FALLS.

On the fifteenth of November, eighteen hundred and twenty-two, water was let into the canal and navigated by boats drawing two feet of water, from Little Falls to Schenectady. From the latter place to Albany the canal was completed, embracing twenty-nine locks, and the water was let in October first, eighteen hundred and twenty-three, thousands celebrating the event. Four miles below Schenectady the canal crosses the Mohawk river through an aqueduct seven hundred and forty-eight feet in length between the abutments, supported by sixteen piers, twenty feet above the river. Twelve miles lower down the canal recrosses the Mohawk on an aqueduct of nineteen hundred and eighty-eight feet in length between the abutments, resting on twenty-six piers. The piers are all

* From William L. Stone's Narrative of Erie Canal Celebration.

built of durable stone, well cut and coursed, and laid in water-lime cement. Two hundred and eighty miles of the Erie Canal was navigated in October, eighteen hundred and twenty-three.

In September, eighteen hundred and twenty-four, there was uninterrupted navigation between Albany and Brockport. This year, three hydrostatic locks were constructed on the canal at Troy, Utica, and Syracuse. The tonnage of boats was obtained by measuring in a pond the displaced water that had been previously gauged in the lock. The capacity of boats, in eighteen hundred and twenty-four, was from thirty-five to forty-five tons. The tonnage going to tide water was five times greater than that coming from it.

On the twenty-fifth of October, eighteen hundred and twenty-five, water was admitted into the Erie Canal, at Black Rock, from Lake Erie, and the same day the first boat ascended the Lockport locks, and passed through the mountain ridge to Lake Erie, thus making an uninterrupted navigation from the Hudson. The admission of water into the canal at Black Rock gave a depth of six feet above bottom from Buffalo to Lockport, as originally located by David Thomas. The water was drawn eastward by a declivity of one inch to each mile.

The Hon. Cadwallader D. Colden, in his memoir of the Erie Canal, written in November, eighteen hundred and twenty-five, says: "The completion of the western section, and, of course, of the whole Erie Canal, was announced to us by the sound of cannon on the twenty-sixth day of last month, and to-morrow we shall witness the

arrival of a canal boat from Buffalo, after an internal navigation of five hundred and thirteen miles ; she will have passed three hundred and sixty-three miles on one continued, uninterrupted, artificial canal, forty feet wide on the surface, twenty-eight at the bottom, with four feet depth of water ; she will have passed through eighty-three locks, built of massive stone, the chambers of which are ninety by fifteen feet, capable of containing boats of more than one hundred tons burthen ; and she will, when she arrives at Albany, have descended five hundred and fifty-five feet ; but her ascent and descent, in the course of her voyage, will have been six hundred and sixty-two feet. The great embankment across the Irondequoit, over which the western section of the canal passes, is one of the greatest works on the canal. This aerial watercourse extends more than a quarter of a mile on a mound of earth, seventy-three feet in height, from a stream flowing through a culvert at its base. The passenger looks down from the narrow eminence on the tops of aged forest trees, rooted in the bottom of the valley. There are works upon the canal which are undoubtedly of a more artificial character, and may appear to some more magnificent ; but when the length, and height, and magnitude of this embankment are considered, and when, above the tops of the trees, boats are seen passing on its summit, which is but little wider than is necessary for the canal and towing path, it must excite great admiration." Upon the middle section there is an uninterrupted level of sixty-nine miles and a-half, and on the western section there is another level of sixty-three miles. The extra-

ordinary lengths of these levels evince the correctness of Mr. Colle's idea, that "the Alleghany mountains died away as they approach the Mohawk. The difficulties which presented themselves on the eastern section appeared more formidable than any that were to be met with elsewhere on the route. The cataract of the Cohoes was to be surmounted; a path for the canal was to be found along the abrupt rocky shores, rising generally to a great elevation, and in many places divided only by the narrow bed of the Mohawk; the upper falls of that river were to be overcome. To accomplish this, and preserve a due level, it was necessary to carry the canal upon a ledge twenty and thirty feet above the base of perpendicular rocks. The ingenuity of our countrymen found, by what they call sand-blasts, means of blowing off such masses of rock that a bed was made for the canal with less labor than had been anticipated. In eighty days the work was accomplished, which, before it was commenced, it was calculated would require several years."

In speaking of this section, the Canal Commissioners in their report of eighteen hundred and twenty-four, say: "None but those who have examined the line previous to the commencement of the work; who had seen the rude and undulating surface which is traversed, the rocks which were to be blasted, the irregular ledges, filled with chasms and fissures, which were to form the basis of a water-tight canal; the spongy swamps and gravel beds, and quicksands, which were to be made impervious to water, and, in short, the huge masses of rough materials, which, with uncommon labor were to be reduced to sym-

metry and form, can easily appreciate the efforts which it has required to surmount these serious obstacles."

The Canal Commissioners do not hesitate to admit that, had this section been commenced while their information as to constructing canals was merely theoretical, probably the attempt to complete it would either have been entirely abortive, or so imperfectly executed as to have defeated the accomplishment of the great work of internal improvements. There are very many objects on the canal which deserve attention, but to notice them would require details which space will not admit ; nor can mention be made of all who have been concerned in the immediate execution of these great works. "But no eulogy could do so much justice as an appeal to their works. It has been said, and it is believed truly, that they have completed, in the shortest time, and at the least expense, the longest uninterrupted canal in the world."

In one of their annual reports, the Board of Commissioners say : "In looking back to the numerous difficulties and responsibilities, some of them of an aspect the most disheartening, which surround the canals, especially in their commencement, we feel compelled by common justice to commend the aid which has at all times been afforded by our engineers. In the selection of all the persons who are now employed by us under this character we have been eminently fortunate. But to the Hon. Benjamin Wright and the Hon. James Geddes the State is mostly indebted. Possessing much local information, competent science, long experience in many kinds of business bearing some analogy to canal operations, and well established

characters for industry and fidelity, these gentlemen have rendered the most essential service in all the duties of their departments. They have unceasingly devoted their best faculties to the great cause in which they were engaged, and they have hitherto been found equal to the high trust confided to them." The report of the Commissioners for eighteen hundred and twenty was accompanied by surveys made by David Thomas of the harbor of Buffalo. They state that "the engineers have devoted themselves to the management and superintendence of the works with a zeal and ability, to which the speed, efficiency and economy with which it has been executed, bears the best evidence; when it is considered that they could have had no experience, that the science they acquired must have been in a great measure the result of mental application, while they were constantly employed in the active and anxious duties of their station, they deserve a commendation, to which anything we could say would be very inadequate."

In a letter from *D. S. Gregory, Esq., to Hon. Benjamin H. Wright, dated Jersey City, June twenty-fifth, eighteen hundred and sixty-six, he remarks :

"Thus I know that the Commissioners thought they must send for some great engineer from England from the Duke of Bridgewater's Canal, to teach us how to build a canal, fearing to trust our common-place Americans. At length they settled upon that plain, unsophisticated, and unpretending land surveyor—nothing but an old-fashioned land surveyor—Benjamin Wright, for the engineer on the

* Mr. Gregory was for many years in the office of the Comptroller of N. Y. State.

Eric, and James Geddes on the Champlain Canal. From this school arose nearly all the canal engineers who have lined the map of the country with their works of internal improvements. What struck me about your father was his modesty and unpretending merit, his quiet way of doing his business, and the immense labor he performed. All the estimates for payment were in his own handwriting, and when he settled up (no forms or blanks were printed in those days), the full statement was made of the work done by the contractor, referring to the contract, and specifying every item, with a summary of all payments before closing, with a receipt in full of the transaction, all in his own handwriting, neat and plain."

In all the exciting scenes of that great celebration, in eighteen hundred and twenty-five, when the waters of Lake Erie were poured into those of the Atlantic, at the right hand of De Witt Clinton was Judge Wright, in calm and dignified satisfaction, receiving the grateful applause of thousands upon the completion of that vast work of international improvement, which was to mark the second epoch in the prosperity of his country.

Long before the Erie Canal was completed, it awakened the spirit of internal improvement in all the Northern and Middle States of the Union. The names of Judge Wright and Judge Geddes, and their able assistant engineers, were everywhere associated with this spirit. As fast as the way became prepared for it, they were called by the different legislative authorities, or canal companies, either as chiefs or consulting engineers, in most of the important works undertaken in the United States, the Canadas, and

the West Indies, upon many of which Judge Wright was engaged as chief or as a consulting engineer.

As early as the year eighteen hundred and twenty, Judge Mills, of Connecticut, applied to De Witt Clinton for advice about an engineer to begin the work of the Farmington Canal. In the reply of Governor Clinton are these words: "We are most indebted to this man" (Benjamin Wright) "for our work." And in consequence of this answer, Judge Wright, in eighteen hundred and twenty-one, was appointed Consulting Engineer on a canal leading from tide water to the Connecticut river, at Northampton, in the very neighborhood where he had gone to the common school in the winter months.

The following year he received a similar appointment on the Blackstone Canal, in Rhode Island, extending from Providence to Worcester. In eighteen hundred and twenty-three he was called in consultation on the Chesapeake and Delaware Canal, in connection with Colonel Totten, General Bernard, and Canvass White, as his associate counsellors. In eighteen hundred and twenty-four he was called to Virginia, in consultation about the canal from Richmond to the Ohio river. Here he was appointed one of the special commissioners to revise all that had been done, and a future examination resulted in his appointment, in eighteen hundred and thirty-five, as Chief Engineer of that important work.

In eighteen hundred and twenty-four he was made Chief Engineer of the Chesapeake and Delaware Canal, and Consulting Engineer on the Delaware and Hudson Canal in eighteen hundred and twenty-five. In eighteen hun-

dred and twenty-eight, General Mercer, President of the Chesapeake and Ohio Canal, visited Judge Wright, in Delaware, and invited him to be the Chief Engineer of that great work, which office he afterwards accepted; and resigned in eighteen hundred and thirty-one.

Judge Wright was now turned of sixty years, and his family, whom he had previously removed to the city of New York, earnestly desired him to spend the remainder of his days in retirement, under his own roof. In accordance with this plan he was, in eighteen hundred and thirty-two, appointed Street Commissioner in the city of New York, but the nature of the office and its duties was as little suited to his tastes as the confinement of it was to his habits, and he retired from it at the close of that year.

But the Harlem Railroad Company did not leave him a day at leisure. He was appointed Chief Engineer on that work, but obtained leave of absence in the autumn to fulfil an appointment for consultation at Montreal, on the Ship Canal of the St. Lawrence. In the next year he returned to Canada as the Chief Engineer on the St. Lawrence Ship Canal, and the Consulting Engineer on the Welland Canal, between Lakes Erie and Ontario.

During this year he was also appointed, by Governor Marcy of New York, to survey the route for the New York and Erie Railroad, under an appropriation from the State, which duties occupied him mainly until eighteen hundred and thirty-six.

In eighteen hundred and thirty-five he was called by the authorities of Cuba to visit Havana, and advise in relation to a railroad from that city to the interior of the

island. The preliminary surveys of this work were carefully examined and approved by him, and its subsequent execution was afterwards continued under the superintendence of his son, Benjamin H. Wright, civil engineer, and Alfred Cruger, Esq., an engineer of experience, the former of whom had previously visited Cuba for the purpose, and succeeded in inciting the authorities to the first step to improvements of this kind on that island.

When Judge Wright's survey of the New York and Erie Railroad was completed, he was invited back to Virginia, but with the understanding that he should give some attention to other appointments. Accordingly, in eighteen hundred and thirty-six we find him Chief Engineer on the Tioga and Chemung Railroad ; and in eighteen hundred and thirty-seven at Chicago, advising about the canal from that city to the Illinois river. With these exceptions, he continued on the Virginia works for several years, vigorously prosecuted the enterprises of the Old Dominion, traversing rivers, climbing mountains, superintending long lines of works, and leading young men in all that requires activity and energy.

Judge Wright died in the city of New York, on the twenty-fourth day of August, eighteen hundred and forty-two, aged nearly seventy-two years, devoting the last energies of a well-spent life in extending and developing the, as yet, half-discovered resources of this great Republic, and leaving behind him a reputation of higher value than riches, and the respect and admiration of a long list of good and great men.

There are men who never directly sought for power or

place, who never sought their own glory, who never ceased from useful labors and never devoted their honest gains to vanity or vice ; the men who have been good sons, good husbands, good fathers and good neighbors ; the men who in all their ends and labors have been real benefactors to mankind. Such men are an honor to any nation, and to their race, and in this class the common voice of his countrymen would place the venerated name of BENJAMIN WRIGHT, THE SURVEYOR AND CIVIL ENGINEER.

CANVASS WHITE,

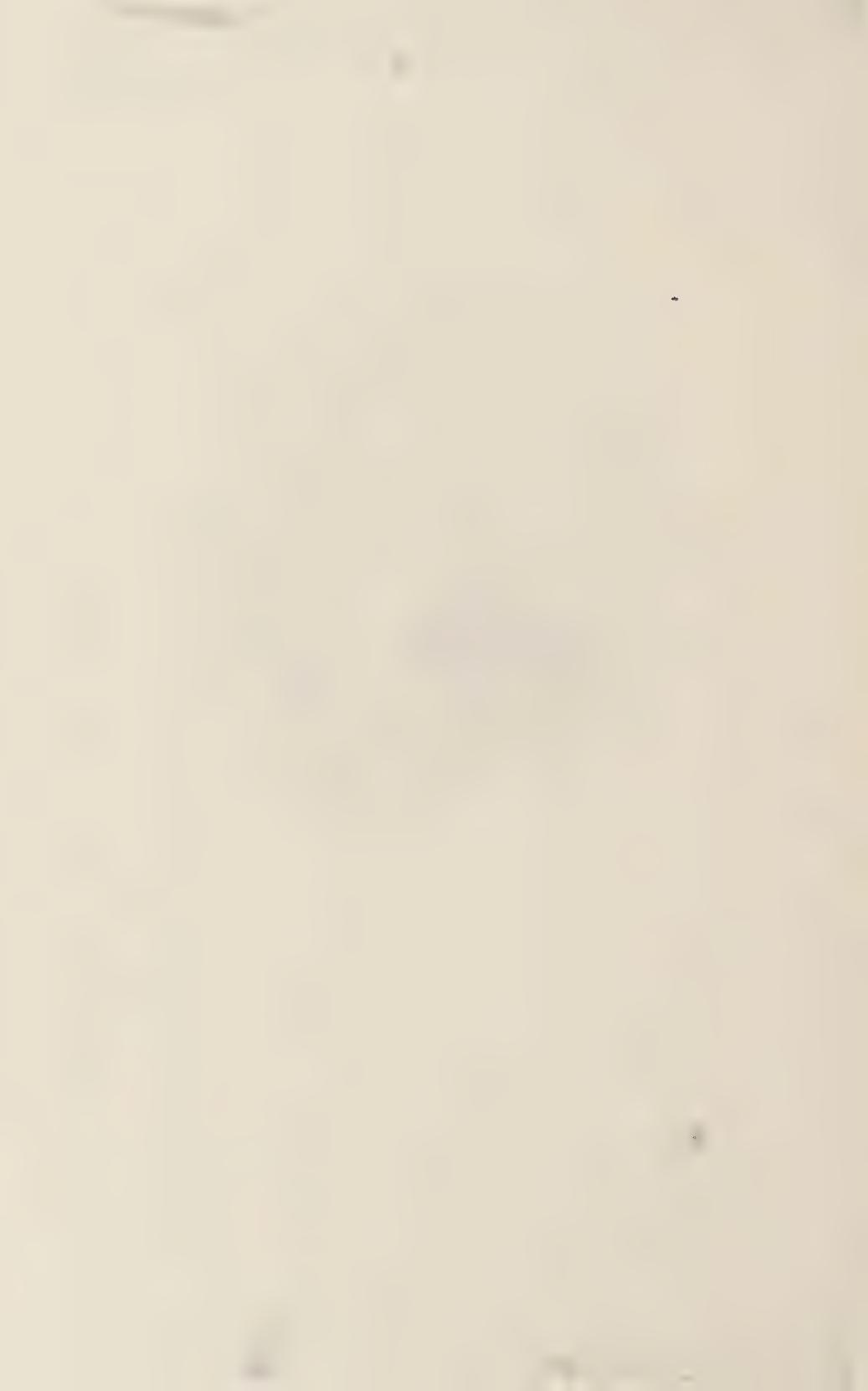
CIVIL ENGINEER.

CONSPICUOUS among the names associated with the early public works of the country stands that of Canvass White, who was born at Whitestown, Oneida County, New York, on the eighth day of September, seventeen hundred and ninety. His father, Hugh White, a native of Connecticut, was a lineal descendant of Deacon John White, one of the first settlers of the present city of Hartford, in the year sixteen hundred and thirty-two. His mother was also of Puritan descent, and from this source he derived those traits of integrity, indefatigable industry, and purity of character, of which his public life was so distinguished an example. His paternal grandfather served during the American Revolution as a quartermaster, and in that capacity, with the self-sacrificing devotion of the many heroes in that first struggle of the country for national life, expended his fortune for the maintenance of the army, receiving in its stead Continental paper money that became worthless in his possession.

Six years prior to the birth of the subject of this sketch, Hugh White, with a family, consisting of his wife, five sons and four daughters, in seventeen hundred and eighty-



George White



four, while "the torch and tomahawk of the savage were yet brandished on the frontier," left his comfortable home at Middletown, Connecticut, and removed to Oneida County, New York, then an almost unbroken wilderness.

His mother, a lady of delicate constitution, unused to the rough exposure incident to pioneer life, died when he was ten years of age. From his mother he seems to have inherited a feebleness of constitution that caused his early years to be a constant struggle between disease and health for the mastery. At an early age he began to display a talent for invention, and a genius for improvements that resulted in the construction of several domestic, and agricultural implements, that were in use for many years on the paternal homestead, and in the neighborhood.

The most of his minority was spent on his father's farm, with such advantages only for acquiring education as the very limited common schools of that period afforded; and it was not until the winter of eighteen hundred and thirteen that an opportunity occurred for him to pursue those studies essential to success in the profession he had chosen. In February of this year he entered the Fairfield academy, and there pursued the studies of mathematics, astronomy, chemistry, mineralogy and surveying, until he completed the course of that institution, after which he continued the study of these subjects under Dr. Josiah Noyes, of Clinton, New York.

At the age of seventeen he entered the store of Colonel Carpenter as clerk, where he remained until the spring of eighteen hundred and eleven, during which time he gained

the entire confidence of his employer and became a general favorite with all his acquaintances. At this time his health becoming precarious, a sea-voyage was advised as a means of restoration. He consequently shipped as supercargo on board a merchant vessel bound to Russia, and did not return to his home until October, eighteen hundred and twelve. The Captain, while in Russia, remained ignorant of the declaration of war and commencement of hostilities between the United States and Great Britain, and took in an assorted cargo, and sailed for Hull, in England. He did not become aware of the war until they entered the English port, and were made prisoners, and their ship and its cargo seized.

For some reason unexplained the Captain and crew, however, were released, permitted to discharge their ship, take in another lading and continue their homeward voyage.

The ship had scarcely cleared the mouth of the Humber when there occurred a violent storm, accompanied by a high tide, and they were driven so far ashore that when the tide receded the ship lay sixty rods from the sea. As the vessel lay on its side, an inspection of the bottom disclosed the fact that the planking, over considerable of the surface, was completely rotten, and that she was utterly unseaworthy. Young White advised that the rotten plank be stripped off and replaced by sound ones, and a channel opened through the sand that would admit the tide to the stranded ship. Work was at once commenced, and a very few days saw the ship that was about to be abandoned by her Captain and crew, re-planked, again afloat, and on her way to New York, where she arrived in the latter part of September.

His health was materially improved by the voyage, and on his return he again entered the employ of his former patron and friend, Col. Carpenter, where he remained until the spring of eighteen hundred and fourteen, when, having raised a company of volunteers, he received a commission as Lieutenant in Colonel Dodge's regiment, and took part in the assault and capture of Fort Erie, opposite Buffalo. While in occupation of the Fort, with his command, he was severely wounded by a shell fired from the enemy's redoubt half a mile distant; soon after his recovery an opportunity occurred for revenging himself on the enemy. A reconnoitering party from the British camp was discovered in an adjacent wood, and Lieutenant White was sent with his command to capture or disperse them. He succeeded in capturing the whole party, killing and wounding several before they surrendered. He remained with his regiment until the expiration of their term of service, when he returned home, and resumed his studies, as previously mentioned.

In the spring of eighteen hundred and sixteen Judge Benjamin Wright was forming a corps for prosecuting the surveys of the Erie Canal. Mr. White solicited a position, and was engaged by Judge Wright as one of his assistants. During this and the succeeding season he was employed in taking the levels westward from Rome. In this duty he acquitted himself so well that he very soon won the esteem of the Chief Engineer, between whom and himself ever afterward there existed a firm and unbroken friendship. About this time he made the acquaintance of Governor De Witt Clinton, who was highly

pleased with his personal qualities and professional abilities.

At this early day the knowledge of canal construction among the engineers of the country was very limited, and Mr. White, at the earnest solicitation of Governor Clinton, determined to visit England for the purpose of examining the public works of that country, and procuring the most improved instruments in use.

In the autumn of eighteen hundred and seventeen Mr. White carried out his determination, and made a careful examination of the canals in the United Kingdom, travelling for this purpose *more than two thousand miles on foot*. He returned in the following spring, bringing surveying instruments and accurate drawings of the most important structures on those works, and much valuable information for the benefit of the State in the construction of its canals. About the time of his return there was much discussion on the subject of lock construction, some favoring wood, and others stone, or a combination of the two. It was, however, finally decided to build stone locks, using quick-lime mortar for the masonry, and pointing the joints with hydraulic cement, then imported at a great cost from England. Soon after, Mr. White discovered a valuable lime rock near the route of the canal in Madison County, which, after repeated experiments, he converted into a cement, equal to the imported, and at much less cost to the State. For this discovery he obtained a patent, but permitted its use under the promise of the Canal Commissioners that a just compensation should be allowed, not only for it, but for his expenses and

services while abroad. The Commissioners, however, failed to obtain the necessary authority from the Legislature to fulfil their promise, notwithstanding the recommendations of the Governor and other officers of the State, as evidenced in the following extracts from official documents :

Governor De Witt Clinton, in a letter to a committee of the Legislature in eighteen hundred and twenty-four, states, "That Mr. White had been of great use in his operations as an engineer; and that his skill, industry, and integrity in that department furnish strong recommendations to the favorable notice of the State." Judge Wright stated before the same committee, "That hydraulic lime had been generally used along the canal since eighteen hundred and eighteen, and part of eighteen hundred and nineteen, in which year, after much persuasion by the engineers, it was used in all face work of locks and arches, the backing being laid in common lime. When common lime was used it gave evidence of soon failing. I have no hesitation in saying that the discovery of hydraulic cement by Mr. White has been of incalculable benefit to the State, and that it is a discovery which ought, in justice, to be handsomely remunerated." Mr. Flagg reported from the same committee that Mr. White, a principal engineer, had made this discovery after repeated experiments, and received a patent in eighteen hundred and twenty. That Mr. White introduced it at great expense amidst the doubts and fears which operate against its use."

The Canal Commissioners, in their report of February, ·

eighteen hundred and twenty, state that, "They have employed exploring parties in both the western and eastern sections. Between the Seneca and Genesee rivers Canvass White, Engineer, has had the charge of a party, which has been engaged for several months in levelling over and surveying different routes for the canal line. These labors he has performed much to our satisfaction, and having presented a view of them to a meeting of our Board held in October, at Utica, we thereupon decided in favor of the route originally explored between these rivers in the year eighteen hundred and sixteen." The canal through, and eight miles east of Utica, was completed in the fall of eighteen hundred and twenty, Canvass White being the Resident Engineer. In eighteen hundred and twenty-one Messrs. Wright (principal) and White (acting), engineers, explored the country thoroughly from Little Falls to the Hudson, and pronounced impracticable the route from Schenectady connecting with the Hudson at Albany, and located the line *via* Cohoes and Troy. This location was finally fixed upon by Messrs. Wright, Geddes, and White. Early in the spring of eighteen hundred and twenty-two Canvass White was sent to lay out the Glens Falls feeder, and in that year he planned and directed the building of the lock and dam between Troy and Waterford, until the eighth of June, when William Jerome took charge.

Judge Wright, in a letter to Dr. Hosack, of December, eighteen hundred and twenty-eight, says: "Here it is proper that I should render a just tribute of merit to a gentleman who now stands high in his profession, and

whose skill and sound judgment, as a civil engineer, is not surpassed, if equalled, by any other in the United States. The gentleman to whom I refer is Canvass White, Esq., who commenced as my pupil in eighteen hundred and sixteen, by carrying the target; he took an active part through that year, and through eighteen hundred and seventeen. In the fall of the latter year he made a voyage to England on his own account, and purchased for the State several levelling instruments, of which we stood much in need. He returned in the spring, and brought with him much valuable information, which he has usefully developed, greatly to the benefit of the State of New York. To this gentleman I could always apply for counsel and advice in any great or difficult case, and to his sound judgment in locating the line of the canal, in much of the difficult part of the route, the people of this State are under obligations greater than is generally known or appreciated."

Simon Guilford, Civil Engineer, in a letter to the author, dated Lebanon, Pennsylvania, December, eighteen hundred and sixty-nine, writes: "In reply to your letter relating to the late Canvass White, C. E., I presume you will obtain, through others, a more extended and connected history, than I am able to give you. I will, however, relate an instance of his prompt decision and energy, which occurred upon the Erie Canal at a time when I was serving him as assistant. When that portion of the canal, along the Mohawk river, between Little Falls and Canajoharie was completed, and the supply of water was turned in, owing to a very porous soil over

which a considerable portion of the canal was made, the supply proved inadequate, which was fully realized as the first boat passed, containing the Canal Commissioners, the principal Engineer, Benjamin Wright, and others. The question arose as to how the difficulty was to be overcome. Mr. White replied, "A feeder must be obtained from the river at this place" (a few miles above Fort Plain), and on being asked how long it would take to build a dam across the river, nine hundred feet long, so as to raise the water nine feet above the ordinary surface, he replied, "*A few weeks.*"

The dam was completed in sixty days, inclusive of a side-cut and bridge connected with it. Trees were cut and taken whole, the trunk with the tops, from timber land near, and placed, with the butts down the stream in parallel rows; the limbs were cut partly through so that they were made to conform closely in line with the trunks, and the cavities filled with rocks and coarse gravel. The trees thus forming the main portion of the dam were weighed down and compacted by a heavy covering of stone material. With the trunks of the lower tiers of the trees left to protrude out several feet from under the lower slope of the dam, an apron or platform was formed, which served as a protection from an under washing of the gravel foundation.

Mr. White's professional success, scrupulous integrity, and modest demeanor, in all transactions of life, won for him the enduring esteem of all with whom he was associated. For these admirable qualities of mind and heart, he became widely known, and, as a consequence, frequent

and urgent offers were tendered him for engineering service in other States. He, however, continued in the active discharge of his duties as engineer on the Erie Canal, until it was so nearly completed, that his place could be supplied from his assistant engineers, when he succeeded Loammi Baldwin as Chief Engineer on the Union Canal of Pennsylvania. He continued in that position until the latter part of the summer of eighteen hundred and twenty-six, when, in consequence of a severe illness, contracted while conducting the surveys of the canal west of the Susquehannah river, he returned to Philadelphia, and resigned his connection with the Company.

The distinguished Civil Engineer, W. Milnor Roberts, in a letter to the author, dated St. Louis, December, eighteen hundred and sixty-nine, writes : "I recollect the first interview with Canvass White, which took place in the office of the Union Canal Company, in Philadelphia. Samuel Mifflin was the President, and my father, Thomas P. Roberts, was, for many years, the Treasurer of the Company. In eighteen hundred and twenty-three and four, Mr. Mifflin had a controversy with Loammi Baldwin, who was at the time the Chief Engineer of the Company, which resulted in the resignation of Mr. Baldwin, and the appointment of Canvass White to fill the vacancy. During the controversy, a long and important paper written by Mr. Mifflin, was intrusted to me to be copied. Curiosity led me to interest myself in the matter under discussion, and in studying the paper I detected what seemed to me to be an erroneous statement, to which, through my

father, I called Mr. Mifflin's attention, who expressed himself under great obligations, as it proved to be important. He urged my father to make an engineer of me ; and he spoke to Mr. White after he had taken charge of the canal ; and some time afterward, when Mr. White visited the office in Philadelphia, I was sent for to meet him. His first remark was: 'He is very small, do you think he could stand rough and tumble engineering?' The interview ended with instructions to me to go up the Schuylkill Navigation on board of a canal boat, and on arriving at Reading, to inquire for Mr. Olmstead, at the Engineer's office. This I did, and in a few days I met Mr. White in Reading, who took me with him in the Company's two-horse wagon on a tour along the line, visiting the works then in the course of construction. This was in the spring of eighteen hundred and twenty-five. Mr. Olmstead who had charge of the eastern division, accompanied Mr. White to the end of his division, where he met Mr. Guilford, who was in charge of the middle division. Soon after Mr. Guilford met us, we came to one of his locks, nearly finished, concerning which, after taking a good look at it, I made my first engineering remark, as follows: 'Why ! Mr. White, don't you think that this lock is too small?' He smiled, saying blandly: 'I guess its large enough.' Mr. Guilford said nothing at the time, but afterwards, when we had arrived at his headquarters in Lebanon, he said to me: 'Don't you know that Mr. White advocated the small locks for this canal, coinciding with Mr. Mifflin in opposition to Mr. Baldwin? You must be careful about what you say

about small locks.' I was young and inexperienced, and my remark became a by-word with the young engineers amongst ourselves. I had then seen only two canals—the James River Canal in Virginia, and the Schuylkill Navigation ; the locks of which were seventeen feet wide and about ninety feet long ; whereas the Union Canal locks were only eight and one half feet wide, and seventy-five feet long ; the design being that two boats from the Union Canal should pass at one time through the locks of the Schuylkill Navigation. I may remark that I have now no doubt that the adoption of so small a canal and locks for the Union Canal, was an error. There had been precedents for such small canals in England ; but I think that the reasoning which determined the size in the case of the Union Canal, on account of the small supply of water, was inadequate, if not fallacious. Many years after its first construction, it was enlarged under the engineering superintendence of my friend, Colonel James Worrall. I send with this my old description of the 'Union Canal,' and of the 'Lehigh Navigation,' copied from my common-place book of eighteen hundred and twenty-nine and thirty."*

"My official or professional connection with Mr. White ended in eighteen hundred and thirty-one." * * *

"Canvass White, in his day, stood at the head of American Canal Engineers, and his strength lay in his cool, practical judgment. He had no experience in railroad engineering, so far as I ever knew. He was a gentleman of very quiet manners, equal temper, and kind

* For a synopsis of the description referred to, see Appendix.

disposition. I never knew him ruffled, or impatient. His wife was a lady of great beauty, and they had a son, a fine boy when I knew him, whom I afterwards lost sight of, who became an engineer."

During the time Mr. White was engaged as Chief Engineer of the Union Canal, he was called to New York for the purpose of examining the sources of supply for pure and wholesome water for the city. He reported to the Mayor and Aldermen, that, for the present need of the city, and its probable requirements for twenty years thereafter, a sufficient supply could be obtained from the Rye pond and the Bronx river, in Westchester County, "but after the city should extend to one-third the surface of Manhattan Island, it would be necessary to add the Croton river to their other resources." The report was accompanied with full details, and strongly impressed the city government with the importance and feasibility of the project.

The comprehensive nature of his mind, through which, at a glance, he grasped the salient points of a subject, and his systematic habit in arranging details, enabled him to accomplish an extraordinary amount of professional work. While engaged upon the two last mentioned enterprises, he was solicited to take charge of the works of the Schuylkill Navigation Company (the Engineer having suddenly died), which was then in the course of construction. After making a rapid survey of the ground, and the plans of the Company, he suggested alterations, and recommended the employment of Captain Beach as their Chief; he continuing as Consulting Engi-

neer, until the work was completed. At this time he was also Consulting Engineer for the Delaware and Chesapeake Canal, Judge Benjamin Wright being the Chief Engineer.

The success and reported profits of the Erie Canal gave an impetus to canal construction in that day, that would have resulted in a system of artificial internal navigation as universal as our present railroad system, could the capital necessary for the purpose have been obtained. Projects were started in various parts of the Union, and a pressing demand was made upon the time of the few engineers then in the country.

The citizens of Hartford conceived the project of improving the navigation of the Connecticut river, and the Windsor Locks were built by Mr. White as Chief Engineer. Careful financial men were led away by the prevailing spirit of the time, and large amounts were expended upon impracticable enterprises.

Amongst these was the Farmington Canal, constructed from New Haven to Farmington, and thence up the Farmington river, "as money could be found to prosecute the work." Mr. White was applied to for plans and surveys, and for an opinion of the value of it when completed; the former of which he furnished, and remained Consulting Engineer during the construction of the work. However, he frequently expressed to Mr. Hillhouse, one of the chief promoters of the enterprise, an opinion adverse to the success of the canal as a financial investment. The capacity of the canal proved to be far greater than the requirements for its construction.

In eighteen hundred and twenty-five, the traffic in coal from Mauch Chunk to Philadelphia had increased to such an extent that the Lehigh Coal and Navigation Company (who were bringing down the products of its mines in arks), finding its means insufficient to supply the increasing demand for coal, concluded to improve the navigation of the Lehigh river, and to ask the State of Pennsylvania to construct a canal along the margin of the Delaware river from Easton to navigable waters below. Josiah White, a member of the Society of Friends, and an energetic man, whose practical common sense and sound judgment enabled him to comprehend men and measures with much precision, was Superintendent of the affairs of the Company, and constructed at Mauch Chunk a wide basin for boats, and one mile of canal, in which were five locks. The work remained in this condition until the spring of eighteen hundred and twenty-seven, when Canvass White, having regained his health, was appointed Chief Engineer, and the work was resumed and prosecuted with such diligence that the first boat passed through the canal in July, eighteen hundred and twenty-nine. At that time the Lehigh Canal was the most capacious work of the kind yet undertaken in the country, and was considered a bold project.

The engineers under Mr. White, were W. Milnor Roberts in charge of the western, A. B. Warford the middle, and John Hopkins the eastern division.

During the summer of eighteen hundred and twenty-five, Mr. White was appointed Chief Engineer of the Delaware and Raritan Canal. He organized a party for

preliminary surveys, and placed it under the immediate charge of John Hopkins, one of his most trusted assistants. This work was discontinued late in the fall, after the location of about twelve miles, and was not resumed again until the spring of eighteen hundred and thirty-one.

The construction of the canal from the Delaware to the Raritan river was attended by many difficulties, and met many obstructions, all of which were successfully overcome. In the prosecution of this important work, Mr. White always acknowledged with becoming gratitude the generous and wise counsel of Commodore Robert F. Stockton, who took an active interest in the success of the enterprise.

In the autumn of eighteen hundred and thirty-four, when this work was nearly completed, his health was so much impaired that his physician advised him to seek a more genial climate, with a probable hope of seeing him restored to health and usefulness. He sailed soon after for St. Augustine, Florida, where he died within a month after his arrival at that place. His remains were returned to New Jersey, and lie buried in the church-yard at Princeton, where his family resided at the time of his death.

Mr. White was personally popular with all who were favored with his acquaintance. General Bernard, a French engineer in the service of the United States, remarked of him, "that as a civil engineer he had no superior; his genius and ingenuity were of a surprising magnitude; his mild and gentle ways, his sweet and amiable temper, modest and retiring manners won his

heart ; he loved him very much, exceedingly." Henry Clay remarked, when speaking of him to a gentleman who was seeking an engineer for the construction of the Chesapeake and Ohio Canal : "Get Canvass White; no man is more competent, no man more capable; and while your faith in his ability and fidelity increases, your friendship will grow into affection."

In a letter from the late Hon. Hugh White, of Cohoes, New York, of July, eighteen hundred and sixty, he says : " My brother, Canvass White, was in stature five feet nine and one-half inches ; lightly made, weighing from one hundred and forty-five to one hundred and sixty-five pounds ; light complexion, light brown hair, blue eyes, wonderfully clear and bright ; inclining slightly forward from a perpendicular when walking or standing. Grave and thoughtful expression, yet full of affection and kindness, a broad intellectual forehead and well-shaped nose, and with a trifle more of flesh would have been an unusually fine-looking man. The most prominent and striking feature in the general contour of the person, was an unmistakable impress of genius, modesty and amiability. In conversation, you could not escape the conviction that what he said he was sure of, and left the impression indelibly upon those he desired to convince of the truth or feasibility of any plan or project he had in contemplation."

DAVID STANHOPE BATES,

SURVEYOR AND CIVIL ENGINEER.

PROMINENT among the distinguished pioneer engineers of America stands honored and admired the name of David Stanhope Bates, who first won a reputation for his professional skill, untiring energy, indomitable perseverance, sound judgment, and exemplary industry, as the principal engineer of one of the important divisions of the Erie Canal.

Thomas Bates, the grandfather of the subject of this sketch, was a native of Wales, and one of a family of ten brothers and two sisters, and was an early settler of the State of New Jersey. One of the brothers, John, was killed at Oswego, New York, during the French war. The other brothers settled in the New England States.

David Stanhope Bates was born at the homestead farm, midway between Morristown and Parsippan, on the tenth of June, seventeen hundred and seventy-seven. His father, David Bates, possessed strong mental qualifications, improved by careful study and deep thought, and was of the medium height, with a compact, muscular frame. He married, in seventeen hundred and sixty, Miss Tappan, of Morristown, an accomplished lady, of

quiet and winning manners. During the Revolutionary War he was an officer under General Washington, and returned to his home only when peace was restored.

David Stanhope was intended by his father for the ministry. After the advantages of a good English school, he passed through a course of academic instructions under the tuition of Rev. Mr. Whelpley, in New Jersey. Upon completing this course, he was placed under the care and tutelage of the celebrated Rev. Dr. Witherspoon, with whom he remained many years, until he became an excellent classical scholar. Notwithstanding his reverence for his preceptor, and his respect for the profession, his mathematical talents inclined him to other pursuits, and he abandoned the study of theology ; but to its influence upon his youthful mind, and to the careful instruction of Dr. Witherspoon, he was indebted for the moral influence that governed every action of his after life.

Upon relinquishing the profession chosen for him, he entered the store of his elder brother as clerk, pursuing meanwhile the study of mathematics. He married, in seventeen hundred and ninety-nine, Sarah Johnson Gould, daughter of Timothy and Susan Baldwin Gould, of Caldwell, New Jersey, and sister of Hon. E. Baldwin Gould, of St. Augustine, Florida. He soon after commenced the mercantile business at Parsippian.

In the vicinity of this village stood the veritable house of "*Old Grimes*," with its "*semicircular garden fenced round with poles*," and at the gate of which young Bates often stopped to talk with the "*good old man*" as he sat at his door. This is mentioned because of the modern

belief that the hero of the song of "Old Grimes is Dead" was a myth. Not so! He really existed; and the author of the quaint verses that have been sung from the "Granite Hills to Texas," was a shoemaker of Morris-town.

In this new home a period of comparative prosperity and happiness succeeded his years of study, until the autumn of eighteen hundred and ten, when young Bates accepted an offer from Mr. George Scriba, a wealthy land proprietor from Scotland, to survey and sell a large tract of land in Oneida County, New York. He accordingly removed with his family to a little settlement, now known as Constantia, on the Oneida Lake.

In the summer of this year, Governor De Witt Clinton "and his associates, the first Canal Commissioners, examined the valley of the Mohawk and the western part of the State of New York, for the purpose of learning the practicability of constructing a canal from the Hudson to the Lakes." Passing around the Oneida Lake he arrived on the fourteenth of July, with his party, at this little village, which he describes in his diary as "Rotterdam, a decayed settlement of George Scriba, situated eleven miles from the outlet, containing eight or ten houses, and marks of premature growth." This now beautifully cultivated portion of New York State, was then almost a wilderness; a remnant of the Oneida tribe of Indians yet lingered in the forests, but they were peaceful and fond of the villagers when unmolested by them.

The establishment of extensive Iron Works at Rotterdam, about this period, by wealthy Eastern parties,

attracted a better emigration thither, and the decayed settlement revived under the influence.

The excellent business qualifications of Mr. Bates enhanced his usefulness in the community, while, with his well-cultivated intellect, he contributed to the improvement of all around him; with ready tact he adapted his method of action to the surrounding elements, and while beloved by his brother pioneers, he was revered and respected by the rude and uncultivated. He accepted an appointment of Superintendent of the Iron Works, pursuing at the same time his favorite occupation of surveying, when his services were required. His evenings were devoted to the study of law, and he became a good counsellor. Subsequently he was appointed Judge of the Common Pleas of Oneida County.

The house of Judge Bates, overlooking the Oneida Lake, was nestled in a grove of native hemlock, tall pines, and other forest trees. The spot selected was singularly wild, yet very beautiful, and there, unfettered and reckless as the Indian children with whom they played, was passed the early boyhood of his three sons, John, Timothy and David, who afterward became distinguished engineers in the service of the State of Ohio.

Judge Bates continued his various avocations at Rotterdam until the spring of eighteen hundred and seventeen, when he applied to Judge Benjamin Wright, whom he had long assisted in surveys, for employment, and received from him the appointment of Assistant Engineer on the middle division of the Erie Canal.

Judge Bates continued in the employ of the State as

Division Engineer, under Benjamin Wright, from eighteen hundred and eighteen to eighteen hundred and twenty-four mainly in charge of the construction of the important work across the Irondequoit Valley, the aqueduct over the Genesee river at Rochester, and the combined locks at Lockport.

The great and constant anxiety of Judge Wright, respecting the proper construction of these difficult works, and his high estimation of the judgment, skill, and integrity of Judge Bates, are manifested in the following extracts selected from letters, written by the Engineer-in-Chief:

“So far as I understand your plan of the aqueduct at Irondequoit, it appears to be correct. I pray you to see that the piles are well and faithfully driven. It is all important to the safety of the whole work that there should be no settling nor any precariousness, as you know that would destroy all instantly. I am glad to hear of your experiment of trying the water on the sand-banks; it will be an excellent thing in any event.” * * *

“The situation of the locks at the Mountain Ridge is such, that three of them, if not more, must be placed within the ridge, combined and doubled. You will understand by this that the line is so steep as to require the locks combined, and the top of the ridge must be blown out to join lock-pits. I hope you will watch the stone-cutters, and check at once any deviation from the right workmanship. I feel alarmed about the water-lime, lest they should not calculate upon the importance of this material. You will see also to the foundations of the

locks, as much depends upon these. Let the sheet-piling below the lower gate be done with the utmost faithfulness, and so close as to be almost water-proof, by battens of thin material, and then puddle each side, allowing the sheet-piling to be at least three or four feet deep below the timber, except where it is too hard to prevent its being drove so deep ; but even there, let it be well done. This part of the work I beg you will attend to personally, as every thing depends upon it.”

In June, eighteen hundred and twenty-two, Judge Wright addressed him thus : “ I feel extremely anxious to have every attention paid to the construction of the Rochester Aqueduct, and I beg you will see that no bad material or ill workmanship is permitted. With regard to the Irondequoit embankment, water should now be brought on to it through a trough, to settle it, after which the safety and durability depends, in a great measure, upon the wooden trunk placed inside, below part of the lining. This operation is to prevent sudden breaking ; it may and probably will settle so as to make some large cracks, but they would be of such a character as to give timely notice of the discharge of water before any great injury could arise. I might say other things, but it is unnecessary. Your good judgment will direct you in all these matters.”

“ The aqueduct at Genesee river will require great attention, particularly the piers ; observe that every part is solid and firm. It is a great work, and any defect in it would ruin yourself as well as me. Let there be very strong bonds in every part, and clamps at the upper end

of the piers, to prevent any stone from being started. I feel great anxiety about these two places—the Genesee river and the Irondequoit embankment—therefore beg you to see to them."

Two plans, contemplating different materials, were proposed for the aqueduct over the Genesee river—one of limestone, similar to that which was finally used upon the enlargement of the Erie Canal. This was deemed too expensive for the country in eighteen hundred and twenty-two, and the plan employing the red sandstone was adopted, greatly to the disappointment of the Chief, and resident engineers, who did not consider the material sufficiently durable for such an important work.



VIEW OF THE AQUEDUCT AT ROCHESTER.

This aqueduct was commenced in June, eighteen hundred and twenty-one, and opened for use early in October, eighteen hundred and twenty-three, and consisted of nine

arches of hewn stone, of fifty feet span each, over the river, and two arches, of forty feet each, over the mill canals, making the total length of this fine structure eight hundred and two feet.

Under an act of the General Assembly of Ohio, of January, eighteen hundred and twenty-three, "authorizing an examination into the practicability of connecting Lake Erie with the Ohio river," two acting commissioners, Messrs. Williams and Kelley, were appointed by the Board of Canal Commissioners of Ohio, to superintend and take the immediate direction of the examination and surveys.

The Commissioners, in their report of January, eighteen hundred and twenty-four, state "that in undertaking a work of so great importance, and involving so much responsibility as that of selecting and locating a line of canal from the lake to the Ohio, it was thought prudent to avail ourselves, as far as possible, of the knowledge which might be derived from the experience of New York in the construction of her canals.

The third annual report of the Canal Commissioners of Ohio, of January, eighteen hundred and twenty-five, states: "They made application to the New York Canal Board, as directed by an act of assembly, for one of the most experienced and distinguished engineers, for the purpose of revising the work."

This application resulted in the employment of Judge D. S. Bates. "Judge Bates arrived in this State about the first of September, since which time he has revised the whole of the lines that have been located, gauged and

measured all the streams relied upon as feeders for those lines, and has fully examined the question of supplying the Tyamochete summit with water. For his views on these several subjects, we beg leave to refer the General Assembly to his detailed and able report herewith submitted."

The skill, energy, and industry of Judge Bates, indicated by the foregoing extract, during the four months following his appointment by the Board as Chief Engineer of the system of the canals of Ohio at that period, are still more strikingly exemplified by the unparalleled amount of professional labor performed by the limited parties under his charge during the following year, as briefly stated in the report of the Commissioners, made January first, eighteen hundred and twenty-five.

"One entire line, extending from Portsmouth, on the Ohio, to the Black River, on the lake ; a line extending from Coshecton to Cleveland, by the way of Tuscarawas and Cuyahoga, the Columbus, and north fork of Licking feeders, and an extra line from the Pickaway Plains to the neighborhood of Chillicothe, have been carefully located, surveyed, and staked out, during the last season. An entire line, extending from Cincinnati to the foot of the Maumee Rapids, with the feeders from the Maumee and Miami rivers, and an extra line extending from Cincinnati, northwesterly about ten miles, have been located, surveyed, and staked out, with equal care, making an aggregate length of canal and feeder lines located during the past season of six hundred and seventy miles."

"We believe the history of canaling furnishes no in-

stance of an equal length of line having been located, and the expense of constructing a canal thereon estimated in the same length of time, nor at so small an expense. There was located in New York, in eighteen hundred and sixteen, about four hundred miles of canal line ; this was accomplished for sixteen thousand nine hundred and thirty-seven dollars, a sum nearly equal to the whole cost of our examinations, surveys, and locations for three years, in which eight hundred miles of line have been actually located and staked out on various routes, and at least two thousand miles of random levelling have been accomplished."

In January, eighteen hundred and twenty-five, Judge Bates presented to the Board of Commissioners his report upon the lines surveyed under his charge and supervision the previous year. Regarding the choice of proposed routes, it was deemed necessary, in order to do "justice to contending interests, as well as to satisfy the candid and prudent of both parties," to obtain the opinion of an engineer of experience and ability, who had formed no previous views on the subject. Judge Roberts, of the New York canals, was therefore called upon for this service, who, after a minute and careful examination, made with the assistance of Mr. Samuel Forrer, of Ohio, and Mr. William H. Price, of the same State, submitted his views, in which Judge Bates, the Engineer-in-Chief, fully concurred.

On the fourth day of July, eighteen hundred and twenty-five, the work upon the Ohio canals commenced at Newark, about the centre of the State, in presence of the

Governor of Ohio, Governor De Witt Clinton, of New York, and many distinguished citizens of the different States. The first shovelful of earth was thrown by Governor Clinton, the second by Governor Morrow, and the third by the Chief Engineer. "But a few weeks were suffered to elapse after the commencement of labor, before the whole line presented an active scene of operations."

Before leaving the State of Ohio, Governor Clinton, with the Chief Magistrate of that State, accompanied Judge Bates and his party over the entire canal route. This was almost the last personal effort of this energetic advocate for the advancement of internal improvements.

Judge Bates continued in the service of the State of Ohio, as Principal Engineer, until March, eighteen hundred and twenty-nine, as will be seen by the following extracts from the report of the Canal Commissioners, dated January, eighteen hundred and thirty :

"Believing that the employment of the Principal Engineer was no longer required by the public interest, the Board made arrangements at the last meeting to dispense with the further services of Hon. D. S. Bates in that capacity. This arrangement took effect on the last day of February, eighteen hundred and twenty-nine. Since that time no engineer of higher grade than Resident Engineer has been in the employment of the Board."

The Commissioners further state, in the same document, that the "locks, aqueducts, and other important structures on the canals have so far fully answered the purposes for which they were designed, and that no seri-

ous injury has been sustained by any of them since their completion."

This fact is certainly complimentary to the Principal Engineer and his assistants, who designed the various structures, and faithfully superintended their construction, upon several hundred miles of canals in the different sections of the State, during a term of nearly five years.

During the time occupied by Judge Bates in charge of the canals of Ohio, about eight hundred miles of canals and feeders were surveyed and located, and four hundred miles placed under contract, and nearly one-half of this distance open for navigation, while the residue was well advanced towards completion, upon the location and plans made under his direction and supervision. They were finally finished under the immediate charge of the several Resident Engineers, who, for many years, had been the assistants of Judge Bates, and for whom he cherished the highest regard and most friendly interests, which were warmly reciprocated by all of them to the period of his death. Two of these assistants, Hon. Jesse L. Williams, of Fort Wayne, Indiana, and Mr. Samuel Forrer, of Dayton, Ohio, have become distinguished in the profession, and highly appreciated as men of worth and integrity. Some extracts from their letters to the author may be found interesting, as showing the strong sentiment of friendship alluded to. Mr. Williams remarks: "The letters of Judge Bates, which I inclose, may serve to indicate character. The re-perusal of them has revived my affectionate regard for one who, at all times and under all circumstances, took the greatest interest in his assistants.

At your convenience these letters may be returned to me, as I do not like to lose any memorial of my kind and revered friend."

Mr. Forrer, of Ohio, in a letter to the author, under date of December, eighteen hundred and sixty-one, thus remarks :

" Judge Bates, of whom I can speak with the utmost pleasure, was employed by the Canal Commissioners of Ohio on account of his experience in constructing canals, for the purpose of revising the locations, and aiding in making the different plans and estimates of the cost of constructing a similar work on each of the different routes, and also for the purpose of reviewing the question of supplying the Tyamochete summit with water."

" Judge Bates, upon a careful reconnaissance of the different surveys, submitted his report, which was very complete and highly satisfactory, to the Board of Canal Commissioners, and coming from an engineer of much experience, acquired on the great Erie Canal, of New York, it commanded the confidence of the people of Ohio in their own engineers, as well as in the projected improvements.

" Familiar with every department of the business of surveying, locating, constructing, and navigating the canals of New York ; with the early mistakes and subsequent improvements in the manner of contracting work, and accounting for receipts and disbursements, down to the organization of collectorships, and establishing rates of toll on transportation, it will be readily perceived that, in addition to his services in the capacity of Engineer-in-Chief, he was invaluable to the Board in all the duties per-

taining to their then official position. Modest and unassuming, he never obtruded his plans and opinions, but gave them on proper occasions in a manner so genial, that they were always received by both compeers and subordinates as favors of great value.

" His urbanity of manner greatly endeared him to all whose fortune it was to serve with him. He gave no orders, but made simple requests as favors to himself, and the result was, that duties were performed with alacrity and pleasure. If he found that an assistant had, from any cause, failed to give a contractor the proper instructions, he would assume the fault as being a want of clear and intelligible instruction by himself. Or if a contractor was not doing his work well, while he would not hesitate to show his dissatisfaction, he always closed his lecture with some amusing story, to convey the idea that he would give him full credit if future good conduct justified it. I once heard him tell a contractor, who was putting earth against a stone wall rather loosely, that he ' did not like to have the puddling done in a manner that would expand the earth so as to make two cubic yards of puddling out of one yard of earth,' then, turning to the Assistant Engineer in charge of the work, remarked, in the hearing of the contractor, ' I must have forgotten to tell you how to have the puddling done, and the contractor has had no instructions, for I see he has done everything else in a faithful manner, and I doubt not he intends to do right, and will, when properly instructed.'

" Although ever vigilant in the inspection of work, and determined to have it well done, he was continually

searching out objects of commendation, upon which he never failed to bestow the proper praise, in a manner which showed that he was really gratified. He was emphatically a gentleman, kind and courteous to all, and of exceedingly honest principles."

In eighteen hundred and twenty-five the Louisville and Portland Canal Company engaged Judge Bates as their Chief Engineer in locating and constructing the canal for the passage of steamboats around the falls of the Ohio river, near Louisville, Kentucky. These duties were performed in conjunction with his professional engagements with the State of Ohio, he having for his assistants his eldest son, John Bates, and John R. Henry, and J. A. Lapham.

On this work he continued in charge until June, eighteen hundred and twenty-eight, when, in consequence of difficulties between the contractors and the Company, he was called upon by the Directors to declare the contract under dispute void. After a careful and minute investigation of the whole subject, he declined to comply with the request, on the ground that the offences charged was not "negligence or an unfaithful performance of work, and did not properly vitiate the contract."

Accompanying this report was the resignation of his office as Chief Engineer, which was accepted by the Company, to take effect in June, eighteen hundred and twenty-eight. He was influenced in this, as in every transaction of his life, by just and honorable principles. Policy might have induced him to another course, but to his free and upright mind, the highest emoluments of office were not

worth possession when gained at the sacrifice of honesty and integrity.

In the spring of eighteen hundred and twenty-nine, after the expiration of his term of service in Ohio, Judge Bates was appointed, by the Canal Commissioners of the State of New York, Chief Engineer in the charge of the surveys and location of the Chenango Canal from Utica to Binghamton.

He completed a thorough survey of the various routes proposed for this canal, and made a full and forcible report to the Commissioners, showing the entire practicability of the undertaking, and that an adequate supply of water could be obtained from artificial reservoirs at the summit. This method was imperative, owing to the statute under which the survey was authorized, which forbid the use of the waters from the Oriskany and Saquoit streams on the summit.

In eighteen hundred and thirty he was appointed by the Board of Commissioners of New York to make the surveys for a canal from Rochester to Olean, on the Alleghany river. This he successfully accomplished, and the canal is now known as the Genesee Valley Canal.

During the next year he made the preliminary surveys for the location of a railroad from Canandaigua to Rochester, and subsequently constructed upon the route he selected, the Auburn and Rochester Railroad, now forming a part of the New York Central.

In the summer of eighteen hundred and thirty-one, he was engaged in the construction and location of the railroad from the city of Rochester to Carthage, at the mouth

of the Genesee river. Upon the completion of these duties, Judge Bates was appointed Engineer of the "Niagara River Hydraulic Company," incorporated for the purpose of improving the water power on that river near Black Rock, in the State of New York. After the fulfilment of this engagement, he accepted an invitation to make the surveys and necessary examinations for a water power on the Niagara river, below the "whirlpool." This work occupied his attention until eighteen hundred and thirty-four, when he was employed as Engineer-in-Chief, by the State of Michigan, to make examinations and surveys for the Erie and Kalamazoo Railroad in that State, his son David Bates acting as assistant.

In eighteen hundred and thirty-five, Judge Bates returned to his home in the city of Rochester, with broken health, and unable to attend to further professional calls or duties.

During a lingering illness of nearly four years he was patient and cheerful, though at times under the influence of great suffering from the character of his malady, which assumed the form of pulmonary consumption. Three months previous to his death, he was prostrated by apoplexy, from which he never fully recovered consciousness, and died the twenty-eighth of November, eighteen hundred and thirty-nine, and was buried at Mount Hope Cemetery, Rochester, New York.

Eighteen years of the life of Judge Bates were passed in active service upon the public works of the different States, in most instances in charge of heavy and very responsible duties. The internal improvements of Ohio

and Kentucky following the completion of the New York canals, occupied his time nearly seven years.

At this period American engineering was yet in its infancy. The now flourishing States were then continued forests, broken only occasionally with newly rising settlements ; and the canals, that were essential to their growth and to the progress of the improvement of the country, traversed sections of swampy and malarious districts. To this poisonous atmosphere the engineers were exposed, remote from home and domestic comforts. A great work was before them, the success of which depended upon their skill and rigid economy. Those were indeed years of wearisome labor to the self-denying pioneer engineers, who patiently and perseveringly gathered the knowledge and experience from which many of the profession have since won an easier way to distinction and wealth.

Personally, Judge Bates was of a fine stature, with a commanding figure. His countenance was agreeable rather than handsome, bearing the type of great benevolence. His eyes were black, with a lively but gentle expression. His manner was at all times polished and refined, both in domestic and public circles. In conversation he was cheerful, witty, and often brilliant. He was endowed with a retentive memory, and possessed a happy talent in imparting to others the wealth of his vigorous mind, and became the cherished companion of the intellectual men of the day in the different States to which his professional duties called him.

NATHAN S. ROBERTS,

SURVEYOR AND CIVIL ENGINEER.

AMONG the surveyors and civil engineers who took a leading part in the development of the inland navigation of the State of New York, few were better known than Nathan S. Roberts. As a man of marked and peculiarly American character, and, in his day, of enviable reputation in his profession, Judge Roberts deserves a conspicuous place in the annals of the early engineering of the Empire State.

His forefathers, to use his own words, "were among the earliest Puritans who emigrated from England to join their brothers at the Plymouth Colony, about the year sixteen hundred and forty." There were two brothers, by the name of Roberts, who settled in the town of Auburn, Massachusetts. His grandfather, John Roberts, a grandson of one of these brothers, was slain in the French war, in seventeen hundred and sixty-four, while serving as a soldier under the command of Sir William Pepperell. A wife and several children, among whom was Abraham Roberts (the father of Nathan S.), were left to mourn his loss. Abraham, though born and reared among the rocks of New Hampshire, sought his fortune

in the West Indies. In the course of a few years, having acquired a handsome competence, he resolved, at about the time of the breaking out of the American Revolution, to revisit his native land; but, unfortunately falling into hands of the British cruisers, he lost his fortune as well as liberty, and was forced to serve against the vessels of his country in several engagements. Finally, having effected his escape, he at length established himself in the State of New Jersey at a place called "Piles Grove," where, on the twenty-eighth of July, seventeen hundred and seventy-six, the subject of this sketch was born.

During a large portion of his minority, his best efforts were directed to assist in the support of his parents and younger brothers. After coming of age, he laid out his earnings in the purchase of one hundred acres of new land in the State of Vermont. To this tract, with two axes, and a scanty wardrobe, he repaired on foot, and having, in eight weeks, chopped several acres of heavy timber, returned to Plainfield, N. J., to teach school during the winter. In eighteen hundred and three he visited the State of New York to examine some wild lands he had bought in Oneida County.

In eighteen hundred and four he settled in that county, and taught a school at Oriskany, and in eighteen hundred and six he was appointed Principal of the Academy at Whitesboro', in the same county.

During the year eighteen hundred and sixteen, Judge Roberts married Miss White, the grand daughter of Judge White, of Whitesboro'. In this year he purchased a

farm in Lenox, Madison County, New York, which was his home during the remainder of his life.

In July of this year, at the solicitation of Benjamin Wright, Judge Roberts first entered upon the career of a civil engineer. With the necessary men, teams, tools, provisions, and tents, he proceeded to make a survey of the route of the middle section of the Erie Canal to Montezuma. The winter of eighteen hundred and sixteen and seventeen was spent at Rome, in preparing maps and profiles of the line recently explored, and in the following spring this section of the canal was located and staked out, Judge Roberts being employed on it as Assistant Engineer. In eighteen hundred and eighteen he was employed through the winter as Resident Engineer in charge of the work from Rome to Syracuse, and in the spring was placed in charge of a party to locate the canal from Syracuse westward. This location, commenced on the twelfth of April, was completed to the Seneca river the last of July, and the work contracted in the summer of that year.

In the spring of eighteen hundred and nineteen Judge Roberts located the Erie Canal from Seneca river to the village of Clyde, and the work was placed under contract in May and June of that year. In the winter of eighteen hundred and nineteen and twenty he made the plans for the locks between Clyde and Rochester, and in the spring located the canal down the Clyde river, and through the Cayuga marshes, on the line explored by him the previous fall. He continued in charge of this work until near its completion in eighteen hundred and twenty-two, when he

was directed by the Canal Commissioners to take charge of the locks at Lockport, and to superintend the construction of the canal to its western termination.

Judge Roberts continued in charge of the work from Lockport to Lake Erie, from eighteen hundred and twenty-two to eighteen hundred and twenty-five. At Lockport a bold, rocky ridge or spur of mountain, rising abruptly, presented to the inexperienced eye an almost insuperable barrier to the westward progress of the canal. A rise of some sixty feet was to be overcome, followed by a cut thirty feet deep and over seven miles in length. Many intelligent men were disposed to view this as an insurmountable obstacle to the successful completion of the enterprise. Here was required a system of combined locks such as had never been constructed on this continent, and the skill, ingenuity, and inventive genius of the whole corps of engineers in the employ of the State was called into requisition by the Canal Board for the production of the best plan of construction. On a given day plans, estimates, and specifications were ordered to be laid before the Board by the several engineers in the employ of the State. Judge Roberts on this occasion exhibited all those qualities which denote the ready resources of the skilful engineer, and gained a triumph rarely won by the most eminent in his profession. He justly took much pleasure in alluding to it, in after years, as the proudest triumph of his long professional career.

Without consulting any one; with but little aid from published works on the subject of engineering, he proceeded to draft his plan for the proposed structure. It

consisted of five double-combined locks, of twelve feet lift each, working side by side. His plan was one that would involve a large expenditure of money to test the practicability of an enterprise upon which the eyes of the public were directed with much interest and anxiety.

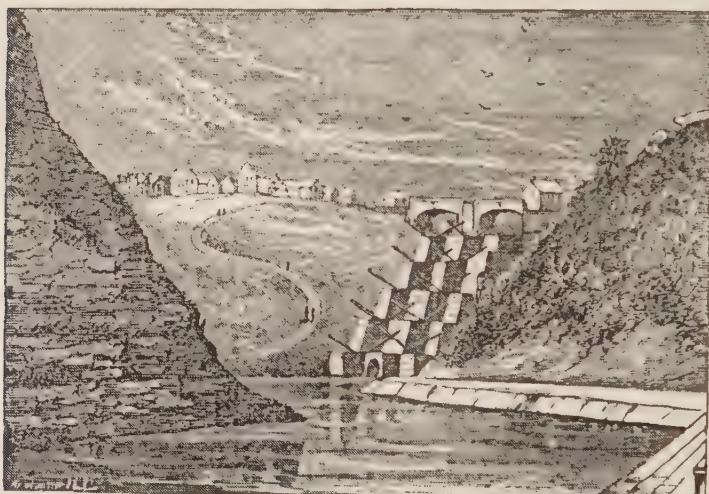
He had the satisfaction of being able to lay before the Canal Board his plan, complete in all its details of construction and operation, and of having it (over many others) unanimously adopted, and himself appointed to superintend its construction. On the eighth of July, eighteen hundred and twenty-three the first stone in the foundation was laid by Judge Roberts, in the presence of a numerous concourse of citizens.

In September, eighteen hundred and twenty-four, the first canal boat arrived at Lockport from the east, and the first one that entered the basin was the "Roberts," Captain Hunter, a boat of about forty tons burthen.

On Thursday, the second day of June, eighteen hundred and twenty-five, the water from Lake Erie was let into the canal as far as Tonawanda Creek, and on the day following, the first boat passed up the canal to Black Rock Harbor, which event was handsomely celebrated by the citizens; and on the fifth of June the Marquis de La Fayette was received at Black Rock with great demonstrations of joy by the people, on his way down the canal on the boat "Seneca Chief." On Friday, the twenty-fourth of June, eighteen hundred and twenty-five, the coping-stone at the head of the ten combined locks at Lockport was laid with Masonic honors; several lodges

and chapters being present, and an immense collection of citizens of Western New York.

On the twenty-fourth of October, eighteen hundred and twenty-five, a little over three and a quarter years from their commencement, the combined locks were so far finished as to allow the passage of boats, and were found to be a complete success.



COMBINED LOCKS AT LOCKPORT

Judge Roberts continued on the western division of the Erie Canal until the whole was completed. Immediately after the celebration of this successful achievement he was called to the Chesapeake and Delaware Canal as one of a Board of Consulting Engineers. In the ensuing January he was employed by the State of New York to make a survey of a route for a ship canal around the Falls of Niagara. Having completed this survey and reported the result of his labors, he accepted an appointment as

Chief Engineer of the canal from Pittsburgh to Kiskiminetas, in Pennsylvania.

During the time he was employed in this work, and while on a brief visit home, he accepted a call from the New York State Canal Board to investigate and report upon the feasibility of supplying the summit level of the Chenango Canal (then projected) with water. This important investigation he accomplished in the most thorough manner in the short space of three weeks, and embodied in a full report the result of his examinations, which was highly satisfactory to the Canal Board and gratifying to the friends and advocates of the project.

Immediately following this, he received two applications for his services—one from the Governor of Pennsylvania, and the other from the Secretary of War of the United States, to review the estimates of the line of the Chesapeake and Ohio Canal, with both of which he proceeded to comply, in the latter finding himself associated with Judge Geddes, of his own State.

This was followed by another appointment from Pennsylvania, as Chief Engineer of the Pennsylvania Canal, which he accepted, and proceeded to examine the country from Johnstown, on the Conemaugh, to Franktown, on the Juniata, for a railroad or portage, to connect the canal. In these responsible duties he continued until December, eighteen hundred and twenty-eight, when, receiving a more lucrative appointment from the Chesapeake and Ohio Canal Company, as a member of the Board of Engineers, he entered upon that duty, and during the same season completed the revision and location of the canal

from Cumberland, in Maryland, to Pittsburg, Pa. During this and the succeeding year, he extended the Chesapeake and Ohio Canal from the Point of Rocks to Harper's Ferry, a distance of twelve and a-half miles. During this time he was also associated with Jonathan Knight as a Commissioner of the Baltimore and Ohio Railroad Company.

During the autumn and winter of eighteen hundred and thirty he was stationed at the city of Washington, employed in superintending the first division of the Chesapeake and Ohio Canal.

After a respite of a few months, during which he visited his home, he received, and, after much hesitation, accepted service from the Federal Government in making an examination of the Muscle Shoals in the Tennessee river, in the State of Alabama, with a view of opening a ship-canal around the shoals. As Chief Engineer in charge, for two years he labored with indefatigable industry and perseverance.

During the time while thus employed, he was invited to take charge of the canal connecting the Mississippi with Lake Pontchartrain, but having already experienced the evil influences of the Southern climate upon his over-tasked constitution, he concluded to return to the more congenial climate of the North. Previous to his departure from Alabama for his home, he was honored by a public dinner at Florence, as an expression of the high estimation in which he was held by its citizens in both his public and private relations.

On returning home his experience and skill were again

sought by the Canal Board of the State of New York, who, in pursuance of an act of the Legislature, were about to enter upon a series of examinations and surveys, with a view to an estimate of the expense of enlarging the Erie Canal, which was now becoming inadequate to meet the rapidly increasing demands upon its navigation. Accordingly, in the spring of eighteen hundred and thirty-five, associated with Messrs. John B. Jervis and Holmes Hutchinson, Civil Engineers, he entered upon the duties assigned him, and submitted a report to the Legislature of the ensuing year, on which a law was passed authorizing the commencement of the improvement.

In eighteen hundred and thirty-nine Judge Roberts was appointed Chief Engineer of the western division of the Erie Canal, extending from Rochester to Buffalo, where he had the gratification and pleasure of enlarging the works of his earlier construction, to meet the increasing demands of the great and growing inland commerce. He re-built one tier of the combined locks at Lockport, and enlarged portions of the prism of the canal, and in eighteen hundred and forty-one, while engaged in the completion of his last, great work, the Rochester Aqueduct, he was, for political reasons, discharged by the party who had attained the ascendancy in the State the preceding year.

From that time forward, admonished by his advancing years, and the demands of his private estate upon his attention, he bade a farewell for ever to the pursuits of a profession in which he had acquired a full share of fame, and an ample pecuniary independence.

He was the friend and patron of merit, always interesting himself to promote the welfare and advancement of those young men whom he found to be worthy, and struggling for success, without friends or fortune. Such he would encourage by his patronage, counsel, and advice, inspiring them with courage to encounter difficulties with a determination to make their mark in the world. Very many who afterwards became distinguished in the State, can date their first encouragement to action from the time when they witnessed his noble example, and were the recipients of his aid and advice.

In his retirement, he was wont to revive old associations by correspondence with the few surviving co-workers of his earlier days. Among them, his relations of friendship with Governor Bouck continued unabated to the last, and on learning of the fast declining strength of his venerable friend, the Governor wrote him a most friendly and characteristic letter, but before it reached its destination those eyes for which it was intended closed in death, on November twenty-fourth, eighteen hundred and fifty-two, and the earthly career of this distinguished Surveyor and Civil Engineer was forever terminated.





Gridley Bryant

GRIDLEY BRYANT,

CIVIL ENGINEER.

IN the front rank of the self-educated pioneer engineers of this country stands the name of Gridley Bryant, the projector and engineer of the first railroad in America, the inventor of the eight-wheeled car, the turn-table, the portable derrick, the switch, and many other valuable improvements in railway machinery and equipment.

He was born at Scituate, Massachusetts, in seventeen hundred and ninety-eight. His father dying while Gridley was young, and leaving no property, he was thrown upon his own resources and efforts to obtain his living. He remarks in regard to himself, in a letter to the author in eighteen hundred and fifty-nine, "that, having a mechanical and inventive turn of mind, I always managed to get along comfortable. I was generally at the head of the young urchins of our neighborhood, and when there was a fort to be constructed, or a cabin to be built, in our plays, I was always appointed the chief engineer, by common consent, and some of our juvenile structures are still in existence." His mother, observing his aptness for mechanical pursuits, apprenticed him, at the age of fifteen, to a prominent builder in the city of Boston. His industry

and progress were such, that at the age of nineteen, he had the sole charge of his employer's extensive works. When twenty-one years of age he commenced business as a builder on his own account, and continued in this occupation until he commenced the Quincy Railroad in eighteen hundred and twenty-six. His skill, industry, and energy secured for him many important contracts with the United States Government, including the United States Bank at Boston.

In a letter to the author in eighteen hundred and fifty-nine, he says: "My opportunities for schooling were very limited, amounting to only a few months in each year, in a common country school; but I always had an innate desire to understand clearly the why and the wherefore of everything that existed, and I am indebted to the Hon. Edward Everett for many valuable observations in some of his earliest productions in regard to the necessity of studying principles; by which means I have generally arrived at just conclusions.

"I have always had a great desire for books, especially those that treated of mechanics and natural philosophy, and perhaps I have studied as much in my lifetime as people generally do. I have made, I think, some useful inventions; one in particular, which has been in use in every city and village in the country wherever there was a stone building to be erected. I mean the portable derrick which I invented in eighteen hundred and twenty-three, and used in building the United States Bank at Boston. This, with every other of my inventions, I have abandoned to the public. Every railroad in the country

is now using my eight-wheeled car, and I have never received one cent for the invention. My turn-table has also been adopted by all railroads, as well as my switches and turnouts, nor have I been paid for services and expenses incurred in the lawsuits which were commenced against several railroad companies by Winans for his pretended invention of my eight-wheeled car, and which the Railroad Companies have since appropriated to themselves.

"The Quincy Railway was commenced under the following circumstances : The 'Bunker Hill Monument Association' had been formed, and funds enough collected to commence the foundation of the monument in the spring of eighteen hundred and twenty-five. I aided the architect in preparing the foundation, and on the seventeenth day of June following, the corner-stone was laid by General de La Fayette, and I had the honor to assist as master builder at the ceremony. I had, previous to this, purchased a stone quarry (the funds being furnished by Dr. John C. Warren) for the express purpose of procuring the granite for constructing this monument. This quarry was in Quincy, nearly four miles from water-carriage. This suggested to me the idea of a railroad (the Manchester and Liverpool Railroad being in contemplation at that time, but was not begun until the spring following); accordingly, in the fall of eighteen hundred and twenty-five, I consulted Thomas H. Perkins, William Sullivan, Amos Lawrence, Isaac T. Davis, and David Moody, all of Boston, in reference to it. These gentlemen thought the project visionary and chimerical, but, being anxious to aid the Bunker Hill Monument, consented that I might see

what could be done. I awaited the meeting of our Legislature in the winter of eighteen hundred and twenty-five and six, and after every delay and obstruction that could be thrown in the way, I finally obtained a charter, although there was great opposition in the House. The questions were asked: 'What do we know about railroads? Who ever heard of such a thing? Is it right to take people's land for a project that no one knows anything about? We have corporations enough already.' Such and similar objections were made, and onerous restrictions were imposed, but it finally passed by a small majority only. Unfavorable as the charter was, it was admitted that it was obtained by my exertions; but it was owing to the munificence and public spirit of Colonel T. H. Perkins that we were indebted for the whole enterprise. None of the first named gentlemen ever paid any assessments, and the whole stock finally fell into the hands of Colonel Perkins.

"The Quincy Railroad is four miles long, including the branches. I surveyed several routes from the quarry purchased (called the Bunker Hill Quarry), to the nearest tide-water; and finally the present location was decided upon. I commenced the work on the first day of April, eighteen hundred and twenty-six, and on the seventh day of October following the first train of cars passed over the whole length of the road.

"The deepest cutting was fifteen feet, and the highest elevation above the surface of the ground was twelve feet. The several grades were as follows: "The first, commencing at the wharf or landing, was twenty-six feet to the

mile, the second thirteen feet, and the third sixty-six feet. This brought us to the foot of the table-lands that ran around the main quarry ; here an elevation of eighty-four feet vertical was to be overcome. This was done by an inclined plane, three hundred and fifteen feet long, at an angle of about fifteen degrees. It had an endless chain, to which the cars were attached in ascending or descending ; at the head of this inclined plane I constructed a swing platform to receive the loaded cars as they came from the quarry. This platform was balanced by weights, and had gearing attached to it in such a manner that it would always return (after having dumped) to a horizontal position, being firmly supported on the periphery of an eccentric cam. When the cars were out on the platform there was danger of their running entirely over, and I constructed a self-acting guard, that would rise above the surface of the rail upon the platform as it rose from its connection with the inclined plain, or receded out of the way when the loaded car passed on to the track ; the weight of the car depressing the platform as it was lowered down.

“ I also constructed a turn-table at the foot of the quarry, which is still in use as originally constructed. The railroad was continued at different grades around the quarry, the highest part of which was ninety-three feet above the general level ; on the top of this was erected an obelisk or monument forty-five feet high.

“ The road was constructed in the following manner : Stone sleepers were laid across the track eight feet apart. Upon these, wooden rails, six inches thick and

twelve inches high, were placed. Upon the top of these rails, iron plates, three inches wide and one-fourth of an inch thick, were fastened with spikes; but at all the crossings of public roads and drift-ways stone rails were used instead of wood. On the top of these were placed iron plates four inches wide and half an inch thick, being firmly bolted to the stone. The inclined plane was built in the same permanent manner and had a double track.

"The first cost of the road was fifty thousand dollars, and that of the first car six hundred dollars. This car had high wheels, six and one-half feet in diameter, the load being suspended on a platform by chains under the axles. This platform was let down at any convenient place and loaded; the car was then run over the load, and the chains attached to it by being inserted in eye-bolts in the platform, and raised a little above the track by machinery on the top of the car. The loads averaged about six tons each. The next car was made with low wheels, with a strong massive frame. The gauge of the road being five feet, the axles were placed that distance apart, this being the true principle on which to construct railroad trucks, and has been adopted generally in this country.

"When stones of eight or ten tons weight were to be transported, I took two of these trucks and attached them together by a platform and king bolts. This made an eight-wheeled car; and when larger stones were to be carried, I increased the number of trucks, and this made a sixteen-wheeled car. This was used to transport the

columns for the Court House in Boston, each one weighing sixty-four tons in the rough.

"In the course of a few years the wooden rails began to decay, and it was necessary to replace them. This was done by substituting stone in the place of wooden rails, using the stone transverse sleepers that had originally been laid. The same mode of securing the iron plates to the stone was adopted, and every part of the track is as perfect now as it was thirty years ago, although it has been in use ever since, and the Treasurer of the Company informs me that it has not cost ten dollars a year to keep the road in repair.

"All the cars, tracks, and machinery are my original inventions. I never began work of any kind without thoroughly investigating the principles and proportions that would produce the greatest effect; and in building the cars, tracks, and machinery for the inclined plane, and all the hoisting apparatus, none of my first productions were ever altered by myself, nor has any new machinery been substituted, or alteration made by those who have had the management of the road from the time I left it to this day. Most of my original machinery being in use at the present time."*

The car constructed by Bryant had a frame for a body, which consisted of three timbers extending longitudinally, and resting with each end on a cross bolster, to which

* Compiled for this volume from the records in the case of *Winans vs. the New York and Erie Railroad et. al.*, by Hon. Wheeler Hubbell (attorney for defendants), Philadelphia, Penn.

they were firmly bolted ; there being two of these bolsters, each resting upon and across a four-wheel carriage or truck, having centre plates and side bearings of iron, and secured in the middle to each truck by a vertical king bolt, to allow a horizontal swivelling motion between them and the bolsters, similar to the king bolt and bolster of a road wagon.

Each truck or four-wheel carriage was constructed with two heavy timbers, to each of which was bolted an iron axle-tree. The wheels were of cast iron, with inside flanges and treads running upon edge rails. These wheels were about eighteen inches in diameter, and revolved separately upon the fixed axles, and not in pairs with the axles, as in the cars now in use.

The distance between the bearing points of the wheels on the rails was five feet in each truck, and about five feet between the trucks. The gauge of the track was five feet. Each truck had a platform covering of plank fastened to its frame. They had no pedestals or springs, and could be used separately when needed as four-wheel cars.

The main body or frame to connect the trucks, when used as an eight-wheel car, terminated about eighteen inches beyond the middle of each truck. They had no projecting platform or bumper, and in the use of two such cars together their trucks would collide. They were drawn by horses attached to the trucks, and had no arrangement for draft by the body, or for connection in trains, or for general railroad transportation. These cars

exhibited the swivelling principle of two trucks connected to one carrying body, adapted to transporting granite, or other heavy bodies, and not suited to any other purpose. These carriages were continued in use on the Quincy Railroad for twenty-five years.

In the suit of Ross Winans *vs.* the New York and Erie Railroad Company, the Bryant car was put in evidence against the validity of the Winans patent, granted for the eight-wheel car, October first, eighteen hundred and thirty-four, and the jury found a verdict against the patent, upon a legal construction given to the specification by Judge Hall. From this construction of the patent a writ of error was taken to the Supreme Court of the United States, which latter Court confirmed the decision of the Court below. The specification of Ross Winans drew only a distinguishing line between the eight-wheel carriage and the four-wheel carriage, and claimed the general principle of construction of the eight-wheel carriage, where it should have distinguished between Bryant's car and the eight-wheel carriage as constructed and adapted in its combinations and appliances for use in trains at high speed, and for transporting freight and passengers. This was what Ross Winans invented and put into practical operation. His patent failed because it was too broad, and not limited to the actual invention he made.

No railroad invention ever gave rise to more controversy than the eight-wheel railroad car, and in none was greater talent employed on both sides of the question. About five years of time, and two hundred and fifty thousand dollars, were expended in the litigation before a

final decision was obtained against the patent,* and the immense claims, which would aggregate several millions of dollars, advanced under it.

The first practical eight-wheel railroad cars for freight or passengers, essentially alike in their construction and combined principles, were invented and built by Ross Winans, of Baltimore, in eighteen hundred and thirty-four and five, for the Baltimore and Ohio Railroad Company, and these cars were run and used in trains in the general business of that Company upon their road, and upon the Washington branch. Mr. Winans commenced his experiments in eighteen hundred and thirty.

The progress of improvement has developed additional means of giving ease of motion, of comfort, and economy in their use, and improvements in connecting the brakes.

A full record of the career of Gridley Bryant might truthfully be termed the history of a busy and useful life. From early boyhood to a ripe old age we find him constantly and usefully employed upon works in which self was always subordinate to the public good. Before he had fully arrived at man's estate he was sought for, and intrusted with the construction of important public work. His labors were greatly cheered by the society and encouragement of men eminent in science, the arts, and social standing; foremost among them was Colonel Loammi Baldwin, a distinguished Surveyor and Civil Engineer, with whom he was employed in eighteen hundred and

* This decision, while it did not benefit Mr. Bryant pecuniarily, sustained his claim as the first inventor of the eight-wheel car.

twelve, by the Governor of Massachusetts (Hon. John Brooks), in repairing and constructing batteries and other defences for the harbor of Boston, on Governor's Island, and Dorchester Heights.

Mr. Bryant, in a letter to the author, of February, eighteen hundred and fifty-nine, relates many interesting incidents and anecdotes of Colonel Baldwin, who was justly held in high esteem by all who knew him, for his great learning, engineering skill, and unswerving integrity. A warm friendship sprang up between these two men, which continued through life. Mr. Bryant says, "since our acquaintance began, he has been my best and most esteemed friend." He adds, "Colonel Baldwin's father constructed the Middlesex Canal, from Boston to Lowell, a distance of about twenty-six miles, and, if I am not mistaken, *the first levelling instrument ever used in this country was employed in the location of this pioneer canal.*"

A letter from Gridley J. F. Bryant, of Boston, dated the fifteenth of November, eighteen hundred and seventy, in answer to the inquiries of the author respecting the events in the closing years of Gilbert Bryant, says: "My father died at Scituate, Mass., on the thirteenth of June, eighteen hundred and sixty-seven, aged seventy-seven years and ten months. The last few years of his life were marked by no important events, as physical disability unfitted him for any active position. After his invaluable services to the several Railroad Corporations, in the 'Ross Winans Suit,' his health and spirits were impaired by the oft-repeated promises made to him of ample compensation. Owing to business losses he had become quite

reduced in circumstances ; but, about the time of the trial, the near prospect of being again independent recalled for a time much of his former energy, as proved by his rising from a bed of sickness and journeying to New York to be present at the court. After waiting long in expectation of the promised remuneration (being several times assured that his claims would eventually be considered), he was at length forced to the conclusion that he had wasted his time and strength in vain, and that their obligations to him were wholly ignored. With the uncomplaining spirit of a proud and reticent man, he bore his disappointments in silence, and gave up this last hope of his old age. On Christmas morning, of eighteen hundred and sixty-six, he had an attack of paralysis, from which, however, he recovered, but he did not leave his room during the winter. With all his physical infirmities his mind remained as bright and clear as before, and his interest in intellectual pursuits unabated. Only the night before his last attack, he was engaged in reading a scientific work until about nine o'clock. The next morning he rose as usual, and after breakfast went out to superintend some gardening, when suddenly the fatal stroke came. He was assisted to the house, and after a brief interval rallied, and retained his consciousness for an hour or two, during which time he conversed in such firm and earnest tones that his wife could hardly believe, what he felt was sure, that the final summons had come. He gave her the minutest directions in regard to business matters, messages for absent children and friends, and an earnest assurance that he had no fear of death. After this he was carried to his bed and was

soon in strong convulsions, having only occasionally a moment's consciousness, until his departure. When dying he motioned his attendants to place him in an arm chair. This wish was understood and granted. Seated facing a window which commanded a familiar view of the beautiful scenery which he could so well appreciate, on that bright June morning, calmly, without a struggle, he entered into his rest."

GENERAL JOSEPH G. SWIFT,

CIVIL AND MILITARY ENGINEER.

THE events in the brilliant and honorable career of this distinguished engineer are perhaps unparalleled in the history of American engineering, for the rapid advances made in professional promotion, and the varied and responsible duties so early undertaken and so successfully accomplished. His name stands at the head of the Army of the United States as the first graduate of the Military Academy at West Point. His subsequent career strikingly illustrates the power of well-directed talent, energy and industry, combined with a laudable ambition to attain the most important positions of honor and trust, under the fostering influences of our free institutions, which so admirably develop individual as well as national character.

Joseph Gardner Swift was a descendant of Thomas Swift and Hopestill Foster, who were the first settlers of Dorchester, Mass., in sixteen hundred and thirty. His grandfather, Samuel Swift, was a lawyer of Boston, mentioned by the elder Adams in his "Memoirs," who fell a martyr to the cause of liberty, at its dawn, in seventeen hundred and seventy-five. His father, Dr. Foster Swift,

was a prisoner on board the frigate "Culloden," seventy-four, of the fleet of Commodore Rodney, in seventeen hundred and eighty-two, and died a surgeon in the United States Army, in eighteen hundred and thirty-five.

Joseph was born on the last day of the year, seventeen hundred and eighty-three, at the house of his grandfather, Thomas Delano, in Nantucket, and was named by his father in compliment to his old teacher, Doctor Joseph Gardner, of Boston. His academic education he acquired under the tutelage of Rev. Simeon Daggat, at the Bristol Academy at Taunton, where he was prepared for entering Harvard College. In seventeen hundred and ninety-nine the Fourteenth Regiment of U. S. Infantry was encamped on the banks of the Taunton river, and very naturally excited the admiration and attention of a youth of sixteen, and awakened an enthusiasm for military life. By the advice, and with the assistance of General David Cobb, a cadetship was procured for young Swift from President John Adams; and in the year eighteen hundred he reported himself for duty to the veteran Colonel Tousard, at the fortifications of Newport Harbor. He was shortly afterwards sent to the Military Academy at West Point, and graduated at that institution in eighteen hundred and two, at the early age of eighteen, and was immediately promoted Second Lieutenant in the U. S. Corps of Military Engineers and ordered to duty upon the harbor defences of the Atlantic coast.

After six years of experience in this important field of duty, and earning by his talents and skill the three several promotions of First Lieutenant, Captain, and Major of

Engineers, he was employed in fortifying the harbors of New England. Upon the commencement of the war of eighteen hundred and twelve he had reached the rank of Lieutenant-Colonel of Engineers, and was detailed as Aid-de-Camp to Major-General Pinckney, in the Carolinas; and in the same year succeeded the veteran Colonel Jonathan Williams in the command of the United States Corps of Engineers, and Superintendent of the Military Academy, with the rank of Colonel.*

In the following year, Colonel Swift, as the Chief Engineer of the United States Army, under the command of Major-General Wilkinson, won distinction and promotion as Brevet Brigadier-General, "for meritorious services" in the memorable campaigns of eighteen hundred and thirteen and fourteen, on the St. Lawrence river, and the defence of the city and harbor of New York, including Brooklyn and Harlem Heights. For this last service, the city of New York, by her corporate authorities, conferred upon General Swift marks of distinction "*as her benefactor.*" By a singular coincidence that metropolis was saved, twenty-one years thereafter, from a more terrible destroyer than a hostile army, mainly, it is believed, through the skill and presence of mind of this same Engineer, who advised and directed the application of blasting powder to arrest the great conflagration of December,

* "Although the law had contemplated that the Corps of Engineers should be stationed at West Point, its duties soon became so extensive that the Chief of the Corps could not be present continuously at the Academy, but by direction of the President he was, previous to eighteen hundred and fifteen, charged with the administration of its affairs, conveying his orders when absent to the senior Engineer officer at the Institution, who thus exercised the functions of Superintendent."—From "Boynton's History of West Point."

eighteen hundred and thirty-five. For a similar subsequent service at Quebec an English officer was knighted.

After the termination of the war, General Swift became Inspector of the United States Military Academy, which office he held from February twenty-eighth, eighteen hundred and fifteen, to November twelfth, eighteen hundred and eighteen. From November twenty-fifth, eighteen hundred and sixteen, to January thirteenth, eighteen hundred and seventeen, he was also its Superintendent, holding his commission as Chief Engineer of the Army until his resignation in eighteen hundred and eighteen. The President of the United States appointed a distinguished French officer (General Bernard) to examine the sites of, and plans for, the works of defence made by the Engineers of the United States, of which General Swift was the Chief. This action of the Executive caused a number of the subordinate officers of the corps to resign, with their Chief, and to solicit civil service. This procedure wounded the pride of a corps of young men, who had been educated by the nation to plan and construct its defences, and who had won distinction in the late war with Great Britain, and was certainly of doubtful policy. After General Bernard had been recalled to France to become its Minister of War, our Government found the alterations and new plans made and proposed by him to be, in almost every instance, unsuited to our defences, and they were consequently mainly abandoned.

Immediately after General Swift's resignation, he was appointed by the President to the office of Surveyor of the Port of New York, which city he had so ably assisted to

defend in eighteen hundred and fourteen. He discharged the important duties of this office for nine consecutive years. After his retirement from the Revenue service he made some business connections in Wall street, which resulted unfavorably, and induced him to retire for a time to an estate of his wife's in Tennessee, and become a cotton planter.

Owing to the ill-health of his family at the South, General Swift returned with them in eighteen hundred and twenty-eight to the North, and shortly after commenced his career as a Civil Engineer in charge of the Baltimore and Susquehanna Railroad, in Maryland. His marked ability, skill, and energy as an engineer, commended him, in eighteen hundred and twenty-nine, to President Jackson as a suitable person to superintend the harbor improvements on the lakes, then undertaken by the Federal Government, and the industry, talent, and devotion displayed by him in the discharge of this important duty, for sixteen years, fully justified the sagacity and judgment of that distinguished Chief Magistrate. General Swift greatly aided by his untiring efforts and labors to promote the construction of these improvements, and the fact of their commanding importance in protecting and developing the growing commerce of the lakes was established.

Deeply is it to be deplored that the Government has, from causes political or otherwise, allowed these structures, erected at a cost of millions of dollars, to fall into ruin and decay, and thus to fill up the channels and harbors they were originally designed to open and protect.

In the winter of eighteen hundred and thirty and thirty-

one, General Swift constructed the railroad from New Orleans to Lake Pontchartrain, five miles in length, being one of the pioneer railroads of the South, and it is believed *the first railroad in America using iron T rails.*

General Swift won much credit to himself by the skill displayed in the construction of this work through what had hitherto been considered an impassable cypress swamp, almost fathomless, and not susceptible of drainage or piling.

In prosecuting this work he engaged a gang of carpenters and workmen from the North, and between the months of November and May cut a straight line of sufficient width, and four miles long, through this dense swamp, using the cypress trees, from one to two feet in diameter, which they felled, for a massive frame work, built with cross ties and string pieces, and secured by wedges, for the superstructure to rest upon. Around this frame were filled quantities of the "Fossil shells of the mounds," to give it stability and strength, being the first use made of these shells for such a purpose, but which have since been successfully used for the formation of the celebrated "*shell road*" to Lake Pontchartrain, and of the streets of New Orleans.

After the completion of the wooden structure of this railroad, and before the arrival of the iron rails and locomotive engine from England, the Hon. Henry Clay visited New Orleans, with his wife, for a few days. General Swift, in compliment to the early and steadfast friend and advocate of the great national road to "unite the Union," determined to give that distinguished statesman

his "*first ride on a railroad*," before his departure from the city.

Accordingly, he disciplined half a dozen of his carpenters to use iron-shod poles to force over the wooden frame and track a platform car, constructed with wheels of wood, the flanges of which were cut from the pecan tree, by which primitive and novel mode of locomotion a speed of nine miles an hour was attained from the city to the lake, greatly to the amusement and gratification of Mr. Clay and his wife, and which he often afterwards referred to as his "*first ride on a railroad*."



HENRY CLAY'S FIRST RAILROAD RIDE.

In eighteen hundred and thirty-two General Swift succeeded Benjamin Wright as the Chief Engineer of the New York and Harlem Railroad, of which he remained in charge until the following year.

In eighteen hundred and forty-one, upon the recommendation of John Bell, then Secretary of War, President

Harrison sent General Swift on an embassy of peace to the Governors of Canada, Nova Scotia, and New Brunswick.

In the years eighteen hundred and fifty-one and fifty-two he made the tour of Europe, accompanied by his son, McRea Swift, Civil Engineer, the particulars of which are in his diary, and would fill a very large volume of much interest and value.

From boyhood, following the example of his father, it was the habit of General Swift, during his life, to record daily the scenes and events of his life and times. This journal or diary contains also a history of the Military Academy at West Point, the biography of President Monroe, with various essays on scientific and literary subjects, which are left to the disposal of his children and the United States Corps of Engineers.

General Swift was a very vigorous and terse writer, possessed an unusual memory and acuteness of intellect, refined by careful study, and enriched by judicious reading and much intercourse with the world. His conversational powers were of a high order, which, together with his great and varied experience, ardent feelings, and engaging manners, made him the centre of a wide circle of devoted friends.

In the year eighteen hundred and five General Swift married Louisa, the daughter of Captain James Walker, of Wilmington, North Carolina. In eighteen hundred and twenty-nine General Swift removed to Geneva, Ontario County, in the State of New York, and purchased a home on the banks of the Seneca Lake, in that beautiful village,

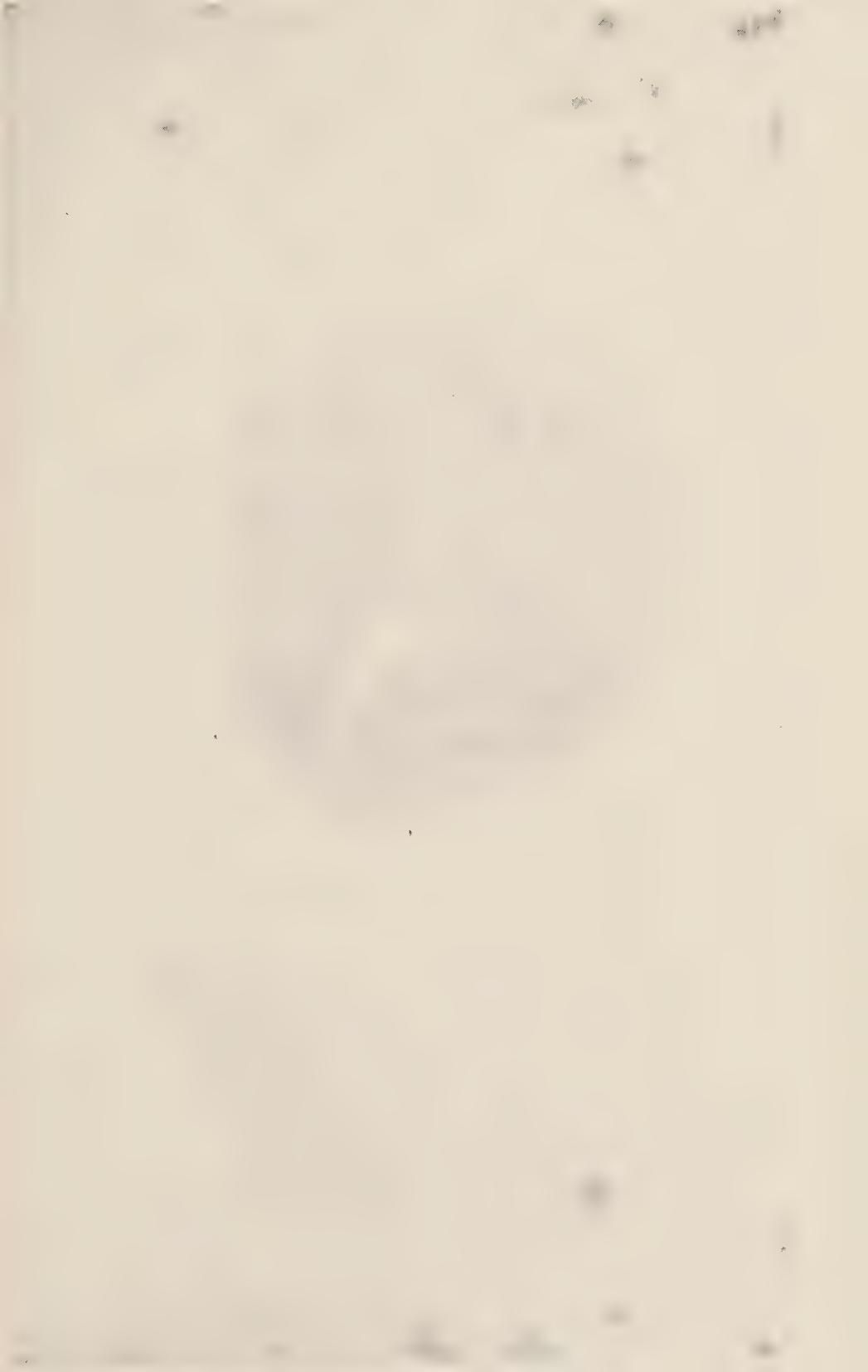
where he reared a large family of intelligent and accomplished sons and daughters.

Two of his sons died in the service of their country—one from exposure in the line of his duty as Civil Engineer ; the other, a promising officer of the United States Engineers, in the Mexican war. Another son, Jonathan Williams, an officer in the United States naval service, was crippled for life on board of the frigate *Brandywine*.

General Swift always interested himself in the passing events and movements of the day, especially in all new improvements, both for utility and defence, and frequently contributed valuable papers to the scientific periodicals of the country.

In a characteristic letter to the author, in eighteen hundred and fifty-nine, he modestly estimates the most important of his long public services to have been the promotion of young men of merit in the army and civil service, for which his official positions gave him many opportunities. In his religious opinions he was a Low Churchman, and in politics a Federalist of the Washington school.

General Swift died at his home in Geneva, after a few days' illness, on the twenty-third of July, eighteen hundred and sixty-five. Rarely has it fallen to the lot of an American citizen to reap a more abundant harvest of honors than those merited by him through the devotion of half a century of life to the civil and military service of his country, and to retire at threescore and ten with so high a reputation and honorable record in the rank of American Engineers.





E. L. Peacock

JESSE L. WILLIAMS,

CIVIL ENGINEER.

JESSE L. WILLIAMS, who for a period of over forty years has been connected with the rise and progress of public works in the States of Ohio and Indiana, was born in Stokes County, in the State of North Carolina, on the sixth day of May, eighteen hundred and seven. His parents, Jesse Williams and Sarah T. Williams, of whom he is the youngest son, were members of the Society of Friends.

About the year eighteen hundred and fourteen his parents removed to Cincinnati, Ohio. For some time after the close of the war of eighteen hundred and twelve, uncertainty attended every business enterprise. This involved the father in pecuniary losses, which prevented him from securing for his young son the most favorable opportunities for acquiring a liberal education. In his early youth the subject of this sketch was one of the pupils of the Lancasterian Seminary at Cincinnati, and afterwards at other places of residence in villages or on the farm, he had only the small educational advantages offered in such locations for the portions of time his other avocations would allow.

After he had chosen a profession, at the age of eighteen years, his mind, one of the most marked traits of which appears in its power of concentration on a single object, was zealously devoted to an investigation of those branches of knowledge which seemed to have the most direct relation to the profession of his choice. In the course of his studies his varied duties in engineering, location and construction, enabled him to combine practice with theory. It seems, indeed, that, trained up amidst pioneer society, he is, in a great degree, like many others in the West, in every profession, self-made and self-educated. The few years which, under more favorable circumstances, he might have passed in college, were employed necessarily in tilling the soil. A vigorous constitution thus acquired, with habits of industry, temperance, and untiring energy, were the compensatory advantages ; and with these sustaining and giving force to an inherent ambition, he was doubtless encouraged in his early manhood to believe that success and honorable distinction in his profession were not beyond his reach.

Although he has often been heard to regret the want of opportunities and leisure in early life for the acquisition of higher attainments in general learning, yet, as tested by the demands of a long, varied, and successful professional career, it would seem that the lack of early advantages has been mainly overcome. His acquirements, theoretical and practical, under the guidance of a sound and discriminating judgment, have been adequate to the faithful discharge of the difficult and complex duties of the various official stations in which he has been placed.

The year eighteen hundred and twenty-five was marked by an achievement in practical science and statesmanship which, for the times, was bold and far-reaching in results. The completion of water communication between Lake Erie and tide-water placed the State of New York in a greatly advanced position, attracting the attention of the Union. Other States caught the spirit of internal improvement. Ohio accepted it as her mission to extend the line of artificial water communication from the Lakes to the Ohio river.

It was under the inspiration of these works of internal improvement, great for their day, that the subject of this memoir, then on the farm in Indiana, was permitted, at the age of seventeen, to take a subordinate place in the Corps of Engineers, which, early in the year eighteen hundred and twenty-four, had been detailed in charge of Samuel Forrer, Civil Engineer, to make the first survey of the Miami and Erie Canal from the city of Cincinnati to the Maumee Bay. In this corps his position was that of rodman, and his pay nine dollars per month. The line of the survey, for the distance of half its length, lay through an unbroken wilderness. On one continuous section of forty miles no white man was found.

Mr. Williams continued to serve in the Corps of Engineers under Mr. Forrer, in the final location and construction of the Miami and Erie Canal, and had charge, as assistant, of the heavy and difficult division next to Cincinnati. He was present at the formal breaking of ground in Ohio by De Witt Clinton, and, with other youthful engineers in the service of the State, it was his fortune to

take the hand of that great man and to receive from him kind and encouraging counsel, prompting to perseverance, and expressive of ardent hopes that the young engineers in his presence might attain honorable distinction in their chosen profession, which was at that time so intimately related to the growing enterprise of the country.

On account of the sickness of the Principal Engineer during the latter half of eighteen hundred and twenty-seven, his active duties were temporarily extended over the whole work between Cincinnati and Dayton.

In the spring of eighteen hundred and twenty-eight the Chief Engineer of Ohio, David S. Bates, appointed Mr. Williams to take charge of the final location of the canal from Licking Summit, near Newark, to Chillicothe, including the Columbus side-cut; and after the line was located and placed under contract, the construction of the division between Circleville and a point south of Chillicothe, was committed to his supervision. Among the works on this division which required in their construction great care and skill were the dam and aqueduct across the river Scioto.

In the autumn of eighteen hundred and thirty, the Canal Commissioners of Ohio appointed a Board of Engineers to examine and decide the very responsible question of supplying with water the summit level of the Miami and Erie Canal, whether by a system of artificial reservoirs or by long feeders from distant streams. Mr. Williams, then twenty-three years old, was appointed one of this Board. Reservoirs were recommended for the main supply, one of which is still in advantageous use,

covering fifteen thousand acres, and is probably the largest artificial lake anywhere known.

Early in the year eighteen hundred and thirty-two Mr. Williams was invited by the Board of Commissioners of the Wabash and Erie Canal, to take charge, as Chief Engineer, of the location and construction of that important work, then about to be commenced by the State of Indiana. The appointment was accepted.*

In eighteen hundred and thirty-four Mr. Williams was appointed, with William Gooding as associate engineer, to survey the White Water Valley, for the purpose of determining the practicability of constructing a canal through that valley to Lawrenceburg, on the Ohio. Their joint report was made to the Legislature, and published among the documents of the session of eighteen hundred and thirty-four and five. At this session the Legislature passed an act authorizing the making of surveys and estimates for canals and railroads in almost every part of the State.

The several surveys of new canals in Indiana, ordered by the Legislature, in eighteen hundred and thirty-five, were placed under his general supervision, in addition to his

* "This canal was constructed literally through a wilderness and in places amongst Indian villages and wigwams. At the village of White Raccoon, the log cabin of Cha-pine, a Miami chief, the orator of the tribe, was found to stand exactly on the line of the canal, and was necessarily moved and rebuilt at the expense of the canal fund, and to the great disgust of the Indian. When the engineer's stakes were first driven and marked by the side of his cabin, Cha-pine inquired their meaning. On being told that a canal, or, to bring it to his comprehension, a river, was to be made, his incredulity found this contemptuous expression: 'Can't do it; wont rain enough to fill it; white man a fool; the Great Spirit made the rivers.' The idea of bringing in the distant St. Joseph of course did not enter his untutored mind;"—From "Stuart's American Engineering," in advance of publication.

charge of construction on the Wabash and Erie Canal, and throughout that year his professional duties were exceedingly diversified and laborious. Still, they were regarded by him as intensely interesting. A single exploring party, engaged under his directions, in ascertaining, in advance of the surveyors and for their guidance, the relative heights of various summits, and of the watercourses for the supply of the canals, ran accurately a continuous line of levels six hundred miles in extent between early spring and the succeeding autumn. More than five hundred miles of definite location of canal lines were made by the different locating parties, and estimates thereof were reported to the Legislature in December, eighteen hundred and thirty-five, by the respective engineers under whose especial charge these surveys were made, with the general advice of Mr. Williams.

On the passage of the law authorizing a general system of internal improvement, approved January twenty-seventh, eighteen hundred and thirty-six, Mr. Williams was appointed Chief Engineer of all the canals of the State, including the Wabash and Erie Canal.

At this period he had under his charge the several canal routes, amounting to about eight hundred miles, portions of which, on each work, were in progress of location and construction. In September, eighteen hundred and thirty-seven, the Chief Engineer of railroads and turnpikes having resigned, these works (also under like progress) were, by the action of the State Board of Internal Improvement, placed under the charge of Mr. Williams as State Engineer ; his supervision then embraced more than

thirteen hundred miles of authorized public works. Afterwards, when the appointing power was changed, he was elected by the Legislature to the same position, and continued therein until eighteen hundred and forty-one, when the prosecution of the public works, except the Wabash and Erie Canal, was entirely suspended.

Perplexing duties and great labors and responsibilities were necessarily attached to the position which he so long occupied as State Engineer of Indiana. The general principles of every survey and location, the plans of every important structure, and the letting of all contracts, came, in their order, under his supervision.

In the course of the summer and autumn of eighteen hundred and thirty-eight no less than thirteen public lettings of contracts took place by order of the Board of Internal Improvement. These lettings, which were held in different parts of Indiana at intervals of about two weeks, embraced portions of each work included in the general system of internal improvements which had been adopted by the State. With such facilities for travelling as belonged to that period, a punctual attendance at the numerous lettings, and the making of necessary preparations for those meetings of contractors, must have taxed the mental and physical energies of one man in no common measure. It was computed at the time by those who felt some interest in such matters, that the journeyings of the State Engineer, performed mainly on horseback, during the three months, amounted to at least three thousand miles. These facts illustrate in some measure the difficulties that were encountered and overcome by

the pioneers in the earlier improvements of the Western States.

After March, eighteen hundred and forty, Mr. Williams, in addition to his duties and responsibilities as State Engineer, became, by appointment of the Legislature, ex-officio a member of the Board of Internal Improvement, and acting Commissioner of the Indiana division of the Wabash and Erie Canal. In the discharge of the various duties of these stations, he acted for a period of about two years, having charge also of the selections, management, and sales of the canal lands. It may be of historic interest to state that the grant of alternate sections of land by act of Congress of March second, eighteen hundred and twenty-seven, to aid in building the Wabash and Erie Canal, was the initiation of the Land Grant policy, which has since given a financial basis to so many of the leading public works of the country. As State Engineer, the public works in every part of the State were under his general charge from eighteen hundred and thirty-six to eighteen hundred and forty-two, and his special supervision of the Wabash and Erie Canal was continued during this period.

The prostration of State credit that followed the financial revulsion of eighteen hundred and forty checked the progress of public works in the United States. From eighteen hundred and forty-two to eighteen hundred and forty-seven, the subject of this memoir was occupied in mercantile and manufacturing pursuits at Fort Wayne, the place of his residence. Before leaving the capital of the State of Indiana he was offered the Presidency of the

Madison and Indianapolis Railroad, then about to be completed under the management of a company; the offices of President and Chief Engineer being united in one.

After five years' suspension an arrangement was matured for the completion, to the Ohio river, of the Wabash and Erie Canal, and through this, as a basis providing for the adjustment of the Internal Improvement debt of the State. In eighteen hundred and forty-seven the entire canal, with its lands, passed into the hands of a Board of Trustees, representing both the State and the holders of her bonds. The law creating this trust, and providing for the adjustment of the State debt, and the completion of the canal, required the appointment of "a Chief Engineer of known and established character for experience and integrity." To this responsible position Mr. Williams was appointed in June, eighteen hundred and forty-seven, at that date resuming the charge of this work, after five years' retirement. He yet occupies this position, with the sanction of the Trustees and that of the Governor, thus making his professional charge of the Wabash and Erie Canal extend over a period of thirty-four years,* having at the same time official connection with important railroads during the last seventeen years.

In February, eighteen hundred and fifty-four, he was appointed Chief Engineer of the Fort Wayne and Chicago Railroad, which position was held up to the time of the consolidation with the Ohio and Pennsylvania, and Ohio

* During the last ten years the canal duties required but little personal attention from the Engineer, though as this office was established by the law creating the canal trust, it could not with propriety be relinquished.

and Indiana Railroads, in eighteen hundred and fifty-six. From that date to eighteen hundred and seventy-one, fifteen years, he has been a Director of the Pittsburg, Fort Wayne and Chicago Railroad.

In July, eighteen hundred and sixty-four, Mr. Williams was appointed by President Lincoln a Director of the Union Pacific Railroad on the part of the Government. The term being but one year under the law, he was re-appointed each succeeding year until the work was completed in eighteen hundred and sixty-nine, receiving commissions from three successive Presidents.

As a member of the Standing Committee on Location and Construction, the important engineering questions connected with the location and plan of this work across the mountain ranges of the Continent, came within his sphere of duty, and called into exercise the professional experience which forty years of public service enabled him to wield. The engineers of the Company, themselves no doubt competent, appear to have treated Mr. Williams with great respect. In the fall of eighteen hundred and sixty-four, by invitation, he accompanied the Consulting Engineer of the Company, Colonel Silas Seymour, over the first forty miles of the route, then in process of construction, to a point on the Platte river, west of Fremont.

The proper construction of the road, with a permanence in some degree proportioned to the liberal appropriation by the Government, seems to have early claimed his attention. On the seventeenth of August, eighteen hundred and sixty-five, he wrote to the Hon. Secretary of the Interior as follows :

"It seems to me, both as respects location and the general plan of construction of this great national work, the Government, either through its Directors or otherwise, should exercise more control. Furnishing as it does almost the entire means for building the road, it is contrary to all analogy that the Government should divest itself of power to direct, as respects the leading points in the route and the character of construction, leaving the great subjects so entirely in the control of the Company and the contracting interest."

To which the Secretary of the Interior, entertaining the same general views, replied, August twenty-sixth, eighteen hundred and sixty-five, as follows :

"Your suggestion for the amendment of that act (Pacific Railroad) will be laid before Congress at its next session for legislative action. In the meantime I hope to be able to obviate the defect in the law by convening the Government Directors and several Boards of Commissioners, in conjunction with the Government Engineers, for the purpose of establishing what will, in the future, be regarded as the standard of a first-class railroad."

Mr. Williams, with other Government Directors, attended the Board thus convened, aiding, as far as in his power, in the adoption of a judicious standard of construction, and in establishing the general principles of location.

The policy adopted by the Union Pacific Board, of making very elaborate preliminary surveys, so necessary to the selection of the very best route for this national work, was earnestly seconded by Mr. Williams, as may be seen

in his reports. The surveys of the first Rocky Mountain range were continued on an extended scale during the year eighteen hundred and sixty-six, under the direction of General G. M. Dodge, Chief Engineer. In the fall of that year, Mr. Williams, at the request of his colleagues, accompanied the Chief and Consulting Engineers in a personal inspection of the several lines run. His report to the Secretary of the Interior, of November twenty-third, eighteen hundred and sixty-six,* presents a brief description of ten distinct routes or passes, all examined with more or less care, crossing this range at various points between the cañon of the South Platte, near Pike's Peak, and the Laramie cañon, embracing an extent, north and south, of nearly two hundred and fifty miles. Most of these mountain passes, so far from presenting a feasible route for a railroad, were marked chiefly for the wild grandeur of their scenery. One of these, the Laramie cañon, is thus described in the report alluded to :

“ In eighteen hundred and sixty-five Mr. Case explored, without instruments, the upper portion of this cañon. But until Mr. Evans, in his second attempt, in eighteen hundred and sixty-six, succeeded in running a line entirely through the cañon, it is not probable that any human being, savage or civilized, ever passed through the whole length of this deep and rugged gorge. Its direct length is fourteen miles ; its length by the survey, twenty-five miles ; its course in many places very tortuous, and its vertical walls of rock from five hundred to one thousand five hun-

* Executive Document No. 2, U. S. Senate Special Session, 1867.

dred feet in height. The fall of the stream in places is from one hundred and fifty feet to two hundred feet per mile, and its current, of course, extremely rapid. It is wholly impracticable for railroad purposes."

In striking contrast with this grand mountain scenery, characteristic of the snowy range, whose bold and rugged features warrant the high sounding name of the "Rocky Mountains," Mr. Williams, in the same report to the Secretary of the Interior, describes the route finally adopted, ascending the Black Hill range on a smooth divide at ninety feet per mile, and crossing the summit where the mountain presents a broad and gentle rounded surface, eight thousand two hundred and forty feet above the sea. His description of the route adopted is introduced by the following paragraph :

" Returning eastward from Fort John Buford,* on the Laramie river, to which point our party had extended their reconnoissance, in part to obtain a military escort, which General Dodge deemed a prudent precaution against Indian depredations on the Lodge Pole, we crossed the Black Hills by the Lone Tree and Crow Creek Divide route, which we followed to a point near the travelled road from Denver to Fort Laramie at the eastern base of the range."

During the same reconnoissance, Mr. Williams visited the route surveyed for the Union Pacific Railroad, between Denver City and Berthoud Pass in the Rocky Mountains, from the summit of which the following letter was written by him in September of that year :

* About this time name changed to Fort Sanders.

"Having reached the summit of this grand mountain range, in company with Colonel Seymour, the Consulting Engineer of the Union Pacific Railroad, and Mr. Brown,* Assistant Engineer, my first impulse is to write to my friends at home.

"One of the experimental surveys for the Union Pacific Railroad follows Clear Creek to this pass. That valley was, therefore, our route from Denver, fifty miles east, bringing us through a rich gold mining district. Eight miles back we took saddle horses, rising by a mule trail sixteen hundred feet in the last one and a half miles. The point on which I write is some six hundred feet above the pass, about six thousand seven hundred feet above Denver, and about twelve thousand feet above the sea. It appears to be some two or three hundred feet above the line of arborescence, or 'tree line,' above which no timber or vegetation grows. Patches of last winter's snow are lying around us on northern slopes, and some of them two hundred feet below. The proposed railroad tunnel pierces the mountain far beneath us. From the summit the waters flow to the Pacific through the Colorado of the West, and to the Atlantic through the Platte.

"Peaks five hundred feet, and one a thousand feet higher than this are near us, while Long's Peak, supposed to be nearly fifteen thousand feet above the sea, is in full view

* This promising young engineer, in prosecuting the preliminary surveys of the Union Pacific Railroad further west, during the following year, was killed at the head of his corps by a band of hostile Indians. Another engineer, Mr. Hills, engaged in the locating service, east of the Black Hill range, was also killed by the Indians, about the same time, at the head of his party.

forty miles to the north-east. During the next two weeks Colonel Seymour and myself expect, in company with General Dodge, the Chief Engineer, to look over the routes surveyed across the Black Hill range, one hundred miles to the north of this place.

"The Union Pacific Railroad is under good progress. In November next the locomotive is expected to cross the bridge over the North Platte, two hundred and eighty-five miles from Omaha. The opening of this work across the plains will soon make the people of the States more familiar with this Rocky Mountain range and its grand scenery; and, what is more important, will afford ready access to a new field of enterprise in the work of developing its vast mineral wealth."

The following letter was written by Mr. Williams on the day of his arrival at Fort John Buford, Dakotah Territory, September twenty-seventh, eighteen hundred and sixty-six:

"My last was from Berthound Pass, September eighteenth. The day was delightful. The next day we encountered a snow storm. Stopping half way down the eastern slope of the mountain, we found the snow on the morning of the nineteenth eight inches deep, icicles on the eaves two feet long, and the thermometer only sixteen degrees above zero. West of the mountain range, the snow fell to the depth of two feet, compelling Mr. Brown's engineer party to abandon the survey for the time being, and cross the range for subsistence for the mules. At Denver there was but a sprinkling of snow. Such are the varied meteorological effects caused by difference of eleva-

tion, and the influence of the mountain range, in arresting and precipitating the moisture.

"Passing north to the Black Hills, and beginning the ascent of this range at the Cache-la-Poudre, the largest tributary of the South Platte, which takes its rise in the snowy heights of Long's Peak, we followed on horseback to this place, another of the experimental lines run for the Union Pacific Railroad, crossing at Antelope Pass. Our party in this most interesting reconnaissance consisted of General Dodge, Chief Engineer of the Union Pacific Railroad, Colonel Silas Seymour, Consulting Engineer, and Mr. Evans, the Engineer who made the surveys. Travelling in a north-west direction, we had the snow-capped peaks of the grand snowy range always in view twenty to thirty miles to the left. The highest altitude reached on this survey is eight thousand and fifty feet above the sea. The transition from the sedimentary rocks forming the slope near the base, to the granite which everywhere composes the central and higher parts of these mountain ranges, is plainly marked. In the secondary formation, and lying geologically next above the granite, is observed, near the base of the mountain on both slopes, what our geologist decides to be the veritable "old red sandstone" of Hugh Miller, which the genius of that distinguished devotee of geological research invested with so much interest in the scientific circles of Europe.

"The valley of the Laramie river, in which we have travelled for twenty miles, on the western side of the mountain, is a vast plain without a shrub. It is twenty-five to thirty miles wide. The groves of pine on the

Medicine Bow Mountains, forming its western boundary, and on the Black Hills to the east, is a relief to the view.

* * * * *

"From this point we expect to return over another experimental survey, crossing the Black Hills further north at Evans' Pass, and thence to Crow Creek and Lodge Pole Creek, branches of the South Platte."

In July, eighteen hundred and sixty-seven, Mr. Williams made a tour of inspection over the road to the end of the track, then just leaving the valley of the Platte and entering that of the Lodge Pole, three hundred and eighty-five miles west of Omaha. The last half of that season was occupied professionally in surveys and estimates preparatory to bridging the Missouri river, he being a member of the Bridge Committee. A full engineering report and estimate on three separate routes across this valley was prepared by him, and submitted to the Union Pacific Board, and by them put in print.

On the thirteenth of June, eighteen hundred and sixty-eight, Mr. Williams was instructed by the Secretary of the Interior "to examine and report specifically as to the condition of the Union Pacific Railroad, where it has been constructed or surveyed."

From his report to the Hon. Secretary, August fifteenth eighteen hundred and sixty-eight,* it will be seen that this important duty was performed; that the President of the Railroad Company accompanied him in a special train to the end of the track, then near Rattlesnake Pass,

* Executive Document, House, No. 15, 40th Congress, 3d session.

six hundred and sixty miles out from the Missouri river, stopping to examine every station and all important structures. At the end of the track, a company of United States cavalry, for protection against Indian hostilities, were in readiness, and the whole party, under command of General Dodge, Chief Engineer, passed thence on horseback over the entire line of surveys to Salt Lake, about four hundred miles.

The topographical formation of the region traversed by the first one thousand miles of the Union Pacific Railroad west of the Missouri river, embracing both the plains and the mountain section, was described in his report to the Secretary of the Interior, last referred to, as follows:

"The level plain of the Platte carries the road with moderate grades and excellent alignment, to the eastern base of the mountains, five hundred and twenty-six miles. Hence to the basin of Salt Lake, at the mouth of Weber cañon, about five hundred miles, the mountainous district is encountered. The principal mountain ranges running transversely with the road are, first, the Black Hill range; second, the Rattlesnake range; third, the Continental divide, or watershed; fourth, the Bitter Creek summit; fifth, the eastern rim of Salt Lake basin; and sixth, the Wahsatch range, separated from the Rim only by Bear valley. The entire drainage of this mountainous section between the Black Hills and the Rim of the Utah basin, except as it sinks in the intermediate dry basins, passes by lateral valleys into the two main rivers—the north fork of the Platte, flowing first northwardly, and thence east to the Missouri, and Green river, running southward to the Colo-

rado of the Pacific. Minor valleys, are, of course, found leading the drainage from the ranges into these main rivers in an easterly and westerly direction, and the engineers have been fortunate in finding, through these several lateral valleys, as the Bitter Creek and Black's Fork, for instance, a very favorable route for the railroad. The granite formation, which, owing to its imperishable character, generally prevents a more precipitous and cliff-like surface, is of limited extent on this route, occurring on the entire line only at the Black Hill range for the distance of about twenty miles, and at the western base of the Wahsatch for three miles. The whole line between is in the sedimentary formation, and the sandstone, everywhere predominant, is generally of the most perishable character. The natural action of the elements, through the ages of the past, on the more elevated ranges has disintegrated this sandstone, filling with the debris the valleys and plains between, thus gradually lessening, with the lapse of time, the difference of elevation, and moderating the slopes."

* * * * *

The question of maximum grade on the mountain ranges was, of course, an important one. His official action on this question, referring to the Wahsatch range, is stated in the following paragraph to the Secretary of the Interior, of fifteenth of August, eighteen hundred and sixty-eight :

"It will be observed that the steepest grade is ninety feet per mile, and this was found necessary only on the two main ranges, the Black Hills and the Wahsatch. The shortest curvature is six degrees on each hundred

feet, or nine hundred and fifty-five feet radius. After the location on the Wahsatch range had been made by the locating engineers, with the approval of the Chief Engineer of the Company, further examinations were ordered by the Vice-President, with a view to cheapening and hastening the work on the western slope, using grades of one hundred and ten and one hundred and sixteen feet per mile. I earnestly remonstrated against a ruling grade exceeding ninety feet, for reasons stated in the paper annexed. I trust the change may not be made.

"On the location adopted, a train of cars once on the summit of the Wahsatch range will meet no ascending grade higher than sixty feet per mile thence to the western base of the Black Hills. And so on the trip westward, an ascending grade of sixty feet per mile is the highest to be overcome from the summit of the Black Hills to Salt Lake Valley, and probably to the Humboldt.

"The total ascent to be overcome by a train going west between the Missouri high bridge and Salt Lake Valley, including the elevation lost by intermediate undulations, is twelve thousand one hundred feet, and by a train going east, eight thousand five hundred and seventy feet."

The reasons for adhering to a maximum grade of ninety feet per mile are more fully stated in the following telegram, copied from the report to the Secretary of the Interior last referred to :

TELEGRAM TO OLIVER AMES, PRES'T. U. P. R. R.

"OMAHA, Aug. 6, 1868.

"The undersigned, one of the Government Directors and member of Locating Committee, respectfully but

earnestly remonstrates against any change of final location on Wahsatch range, as made by J. Blickensderfer, Locating Engineer, and approved by the Chief Engineer, which shall increase grades over ninety feet per mile. Having examined the ground, I know this maximum to be feasible at reasonable cost, and that it need not delay your rapid track laying. Ninety feet maximum grade being adapted to the general slope of the Wahsatch, and being the ruling grade from Missouri river to the Sierra Nevada, to exceed it here would materially impair the efficiency of this Continental road, injure both its stockholders and the commercial interests, and increase the hazard of travel over this abrupt and icy range, with only a paltry advantage to the contracting company. If there exists a purpose of increasing this grade, I trust it will be abandoned.

“J. L. WILLIAMS.”

The Secretary of the Interior, in his annual report to the President of the United States, of thirtieth November, eighteen hundred and sixty-eight, referring to this specific examination of the Union Pacific Railroad, says: “Mr. Williams is an experienced Civil Engineer, and performed the duty committed to him in a very satisfactory manner. His report presented such statements that I deem it my imperative duty, on presenting to you the report of the Commissioners on the twenty-fifth section, to invite your attention to the leading facts he communicated, and to request that the Attorney-General be directed to advise you whether said report, as to the facts covered by it, was conclusive upon the Executive.”

The result of the Attorney-General's opinion upon the power of the Government was the appointment, by the President, of a second and larger commission, consisting of three experienced engineers, to wit: Brevet Major-General Warren, U. S. Army; J. Blickensderfer, Jr., of Ohio, and J. L. Williams, of Indiana, to examine and report on the entire road. Mr. Williams, appreciating the high honor of this appointment, especially as it gave assurance of approval by the Government of his course in the important issues raised before the country by his several reports, was nevertheless constrained by other duties to decline. The report of the two engineers above named was confirmatory of his report.

In October, eighteen hundred and sixty-eight, the Government Directors were directed by the Secretary of the Interior to collect from papers in the Union Pacific Railroad Office in New York and report certain information touching, amongst other things, the cost of the road. The books of the office, however, did not furnish the actual cost called for by the Secretary, but only the contract price per mile, known to be large, and the issue of securities. The actual outlay in construction by the contracting company, operating under a charter (the credit mobilier), was to be found only amongst their private papers, to which the Government Directors could not claim access. Under this state of facts Mr. Williams deemed it his duty, as Government Director, to prepare an estimate of the actual outlay by the contracting company in building the road. This estimate was embodied in his report to the Secretary of the Interior, dated Fort

Wayne, Indiana, November fourteenth, eighteen hundred and sixty-eight.* It seems to have been made with much care from personal knowledge and inspection of the road, and which gave an approximate estimate of expenditure necessarily made by the contracting company in building eleven hundred and ten miles of road, from Omaha to Monument Point, in Salt Lake Valley. This report was well timed, and wisely conceived for the public interest. It met so fully the then existing desire for information, as to secure a very wide circulation through the leading newspapers of the country. It attracted much attention in Congress. Of it, the Secretary of the Interior, in his annual report before referred to, gave the following synopsis :

"As the actual cost of this road is a matter of public interest, I deem it proper to present, in a condensed form, the estimates submitted on the fourteenth instant, by Jesse L. Williams, Civil Engineer. He states that the cost of the road as shown on the books of the Railroad Company is, of course, equivalent to the contract price per mile. The actual cost to the contractors forming an association which embraces most of the larger stockholders of the Company, is shown only by their private books, to which the Government Directors have no access. The calculations were therefore made from the most accurate data, and the estimated cost of the first seven hundred and ten miles of the road was taken as the basis for computing that of the whole line. Should the road, as is

* House Executive Document, No. 15, eighteen hundred and sixty-eight.

expected by the Company, form a junction with that of the California Company, near the northern extreme of Great Salt Lake, a little west of Monument Point, its length would be about eleven hundred miles. The cost of locating, constructing, and equipping it and the telegraph line, is thirty-eight million eight hundred and twenty-four thousand eight hundred and twenty-one dollars, an average per mile of thirty-four thousand nine hundred and seventy-seven dollars and thirty-two cents.

"The Government subsidy in bonds for that distance at par, amounts to twenty-nine millions five hundred and four thousand dollars, an average per mile of twenty-six thousand five hundred and eighty dollars. The Company's first mortgage bonds are estimated at ninety-two per cent., and would yield twenty-seven million one hundred and forty-three thousand six hundred and eighty dollars.

'The fund realized by the Company from these two sources amounts to fifty-six million six hundred and forty-seven thousand six hundred and eighty dollars, being an average per mile of fifty-one thousand and thirty-four dollars, exceeding by sixteen thousand and fifty-six dollars and sixty-eight cents the actual cost of constructing and fully equipping the road, and yielding a profit of more than seventeen million seven hundred and fifty thousand dollars."

The tenor of Mr. Williams' reports shows a consistent and earnest opposition throughout to the plan of letting the road in very large contracts, as practised on this road, at a price per mile, so large as to cover the means provided by law in Government and first mortgage bonds,

rather than at a rate proportioned to the amount of work to be performed. It is well known that he ever urged on all occasions a careful husbanding of the large subsidies so liberally furnished by the Government, that there might be means, without resort to excessive rates of traffic, to maintain and strengthen the work during the first few years after opening. A "reserve fund," in Government bonds, to be retained in the hands of the Secretary of the Treasury, and used in bringing up the road to the proper standard, seems, from official reports, to have been his favorite idea. His views on this point are explained in the following letter to the President of the Company, at the close of their examination of the six hundred and sixty miles of track then laid. It is taken from the appendix to his report of August fifteenth, eighteen hundred and sixty-eight, to the Secretary of the Interior :

"END OF TRACK, *July 1, 1868.*

"DEAR SIR,—I beg to submit for your examination the enclosed paper, explanatory of the suggestions of a 'reserve fund.' If not the best, it may lead to a more feasible scheme.

"That there is a practical difficulty in the case all must admit. Your very rapid progress with the track without waiting, in all cases, to build permanent work, is for the interest of both Company and the country, and should be encouraged. But, on the other hand, those representing the Government may well hesitate to sanction the delivery of the entire subsidy, liberal as it certainly is, for the whole extent of the road, while the work is in so incom-

plete a state, as it must necessarily be when each successive twenty mile section is presented for inspection.

"It is unnecessary to remind you of the large expenditure required on any new road just opened, in the way of improvement, enlargement, and equipment, before its facilities are adequate to earn, at reasonable rates, the large sum per mile which we all expect from the Union Pacific Railroad. I respectfully ask of you a careful consideration of this subject, that the true interest both of the Company and the Government, which, it seems to me, do not conflict, may be secured.

"I should add that if the control of the work would certainly remain in the hands of the very respectable and wealthy gentlemen now holding the stock, no such precaution might be necessary, for they would put in fresh money as needed to make an efficient road. But in the ever-changing control of such works, this is not probable.

"Very truly,

"J. L. WILLIAMS,

"*Government Director.*

"OLIVER AMES, Esq.,

"*President Union Pacific Railroad.*"

At the meeting of the Union Pacific Board in September, eighteen hundred and sixty-eight, a copy of his report of fifteenth of August previous was read to the Board. At that time a resolution was offered by Mr. Williams for adoption by the Board, assenting to the proposed "reserve fund" in Government bonds, as suggested by that report, to be retained in the hands of the Secretary of the Treas-

ury. Though not adopted by the Board in any efficient form, the principle was afterwards adopted by the Government, and formed the basis of its action under the opinion of the Attorney-General.

On the nineteenth of January, eighteen hundred and sixty-nine, Mr. Williams was appointed Receiver of the Grand Rapids and Indiana Railroad by the United States Court for the Western District of Michigan.

This work, three hundred and twenty-five miles long, is designed to connect the city of Fort Wayne and the region further south with Little Traverse Bay and the Straits of Mackinaw. In the distribution of the lands granted by Congress to the State of Michigan, this work was endowed with a valuable land grant.

The work was commenced twelve or fourteen years ago. A failure to negotiate its bonds, the natural result, perhaps, of a premature beginning in a district of country so little settled at that time, had caused very serious financial embarrassments, and a suspension of the construction, with only twenty miles in running order. Other and rival interests were watching the haltings of this work in expectation of obtaining a transfer of the land grant for their benefit.

Under the law of Michigan, a failure to complete twenty additional miles by July first, eighteen hundred and sixty-nine, extending northward into the Pineries, forfeited absolutely the land grant, thought to be worth seven millions of dollars. The stake was large, the work to be done remote from settlements, and the time only some fifty days after the yielding of the frost

The Court, for the protection and benefit of all the interests involved, had ordered the Receiver to borrow money by pledge of the land, and build the road as required by law. Seldom has so large a responsibility been laid on any one. For no provision was made for a second effort to recover the land grant, if lost by a single day in the time of completion. Much interest was felt along the line and with capitalists who had already invested largely on the security of the land grant and the road. The following telegram, sent eight days before the time fixed by the statute, announced the result of the effort :

"GRAND RAPIDS, June 22, 1869.

"To HIS EXCELLENCY,

"THE GOVERNOR OF MICHIGAN.

"The last rail of the twenty miles was laid last evening.

" J. L. WILLIAMS."

By further orders of the Court, Mr. Williams, as Receiver, was authorized and directed to build and put in good running order the entire remainder of the line between Fort Wayne and the Muskegon river, a distance of two hundred miles.

In addition to the duties and responsibilities ordinarily belonging to a financial trust like this, he had also the professional charge as Directing Engineer of the work. These several duties were found so exacting as to leave no time for the proper performance of Pacific Railroad duties. He, therefore, in October, eighteen hundred and sixty-nine, resigned his position as Government Director of the Union Pacific Railroad.

After being relieved from duty under the Government, he devoted his whole time and energies to the completion of the two hundred miles of the Grand Rapids and Indiana Railroad north of Fort Wayne, and opened it for traffic early in October, eighteen hundred and seventy. One hundred and sixty miles of track was laid, besides closing up a large part of the grading, delivery of cross ties, etc., from the middle of April to the thirteenth of September, eighteen hundred and seventy, a rate of progress which has perhaps not been equalled on any other work except on the Pacific roads.

The professional life of Mr. Williams has been in a remarkable degree full of useful activity. It is honorably and inseparably identified with many of the great public enterprises which have effected important changes in the condition of the country. Commencing at a time when the superior advantages for the carrying on of inland trade and commerce by means of canals were attracting universal attention to their construction, he will probably close it, long after this kind of improvement has become secondary in importance (except in peculiar localities) to another of still higher perfection—the railroad. Indeed it may be said that, in the regions west of the Alleghany Mountains, he has witnessed *the origin, the growth, the maturity, and the decline of the canal system.*

Turning his attention early to railroad construction, he has devoted the last twenty years of his professional labors, mainly in aiding forward to successful completion some of the most prominent railroads in the country.

COLONEL WILLIAM MCREE,

CIVIL AND MILITARY ENGINEER

COLONEL WILLIAM MCREE was a military engineer at the commencement of the war of eighteen hundred and twelve with Great Britain, and probably at that period the best informed mind of the military men of our country. He was prominent among those who distinguished themselves on the Niagara frontier in eighteen hundred and fourteen, where he won two brevets, and the high regard of the Commander-in-Chief.

Colonel McRee was the son of Major Griffith McRee, of the North Carolina line in the Revolutionary War, and was born in Wilmington, North Carolina, in the year seventeen hundred and eighty-eight. His mother was the daughter of Dr. John Fergus, a distinguished physician of Wilmington, N. C., who had been educated in Edinburgh, and was of Scottish descent.

At the age of sixteen, William became acquainted with Colonel Jonathan Williams, while that officer was on a visit of inspection of the defences of Cape Fear harbor, and the Colonel, discovering a fine mind in the youth, procured for him a cadet's warrant at the Military Academy of West Point. The youth soon evinced a fondness for

mathematics, at the Academy ; was very studious in military history, and became a Lieutenant of Engineers in eighteen hundred and five. Until the "War of Twelve" he was employed in the repairs of the forts on the Atlantic coast. In the year eighteen hundred and sixteen he was associated with Major Thayer in a mission to France and Belgium to visit the fortifications of those countries, and to collect a military library for the West Point Academy, duties which these officers executed with exemplary success and usefulness. In eighteen hundred and eighteen Colonel McRee took similar views as his Chief, General Joseph G. Swift, as to the impolitic mode of introducing a foreign engineer into the United States military service, and after completing the first general survey made by the Board of Military Engineers, he resigned his commission in the United States Corps of Engineers. He was shortly after appointed Surveyor-General of Illinois, Missouri, and Arkansas, and while commanding to the Government very important improvements in that service, he fell a prey to the cholera at St. Louis in eighteen hundred and thirty-two, in the very prime of his life and usefulness.

Colonel McRee was distinguished for quick perception, sound judgment, modesty of deportment, and very studious habits.

He instituted experiments in regard to suitable food and its quantity, to enable a soldier to sustain health with the longest daily march, and came to the conclusion that about half the ordinary ration, suitably prepared, with regular daily exercise, would sustain the soldier in con-

tinued marches of twenty miles per day for one month, and that ground-parched Indian corn, with one-fourth of its weight in sugar, commingled and packed, would enable a soldier to carry ten days' provisions on a forced march. This last fact was proved by General Jackson in a march during the Creek and Seminole war of eighteen hundred and eighteen.

Colonel McRee studied the best authorities with reference to the physical powers of soldiers.

His habits of life were abstemious, and his character and conduct pure. He was never married. His political sentiments were of the most simple republicanism. He had few personal associates, and fewer personal intimacies, though his acquaintance was sought by many for his high attainments and unexceptionable private life.

SAMUEL H. KNEASS,

CIVIL ENGINEER.

SAMUEL HONEYMAN KNEASS was of the list of Civil Engineers who started in their profession with the first project of internal improvements in the State of Pennsylvania. He was born in the city of Philadelphia on the fifth day of November, eighteen hundred and six, and was the second son of William Kneass, who was for many years engraver for the United States Mint. In the year eighteen hundred and twenty-one, he entered the office of William Strickland, the then leading Architect and Civil Engineer of the State, and, with him, assisted in the erection of several buildings that now ornament the city of Philadelphia, among them the United States Bank, now occupied as the Custom House. One of his earliest attempts at architecture was the triumphal arch, erected from his design, at the time of Lafayette's visit, in eighteen hundred and twenty-four, the original drawing of which now hangs in Independence Hall. His inclinations, however, were for the duties devolving more especially upon the Civil Engineer ; he, therefore, directed his attention to that branch, and was engaged at an early date in the field-work, of improvements in charge of Mr. Strickland ; among them was

the survey for the Chesapeake and Delaware Canal. In eighteen hundred and twenty-five he was appointed to accompany Mr. Strickland to England, under the auspices of the "Society for Promoting Internal Improvements," of Pennsylvania, for the purpose of examining and reporting upon the public works of that country. All the drawings which accompanied this report were made by him, and were afterwards copied in the extensive work entitled "The Public Works of Great Britain," published in eighteen hundred and thirty-eight by John Weale, of London. After his return from England, he joined the corps organized by Mr. Strickland for the construction of the Susquehanna division of the State Canal, and, as Principal Assistant Engineer, remained with him until eighteen hundred and twenty-eight, when he was transferred to the Delaware division, with Mr. Sergeant as Chief. In eighteen hundred and twenty-nine he left the service of the State, and assumed the charge, as Chief Engineer, of the Mine Hill and Schuylkill Haven Railroad, from which he retired in eighteen hundred and thirty-one, to leave his native State and commence the construction of one of the first of the chain of Western railroads—the Lexington and Frankfort—but left this road in eighteen hundred and thirty-two to take the position of Chief Engineer of the Philadelphia and Trenton Railroad. Upon the completion of this work, he again left Pennsylvania, and, in Louisiana, started the West Feliciana Railroad; here his health failing, he returned to the Philadelphia and Wilmington Railroad (a portion of the Philadelphia, Wilmington and Baltimore Railroad), at the same time having in charge

the construction of the Delaware and Schuylkill Canal. This latter work was never completed. The former he finished, and remained in the service of the Company until eighteen hundred and forty. Again he visited England, and examined, with care, the improvements in machinery and construction that had been made during the intervals of his visits. Immediately after his return he took charge of the surveys for the extension of the lower districts of the city of Philadelphia, then beyond municipal limits, which, with other work of construction for the city, occupied him until eighteen hundred and forty-three. From this time until eighteen hundred and forty-five—during the time when railroad undertakings were, from the financial state of the country, in a very adverse condition—he was engaged in various sections of the State upon explorations and the examination of projects that waited upon a favorable opportunity for development, and, in eighteen hundred and forty-five, left for South America, as United States Consul at Carthagena, in New Grenada, and as contractor for the construction of a canal from Carthagena to the river Magdalena. In eighteen hundred and forty-six he returned, and took charge of the Wisconisco Canal, on the Susquehanna river, in Dauphin County, Pennsylvania. After finishing this, or nearly so, he was engaged for a short time upon the Pennsylvania Central Railroad; but in eighteen hundred and forty-eight he left this service to take a position upon the Northern New York Railroad, between Ogdensburg and Rouse's Point. In eighteen hundred and forty-nine he was elected City Surveyor of Philadelphia, which post he

occupied until May, eighteen hundred and fifty-three, during which time he constructed the new bridge over the Schuylkill at Market street, and arranged the approaches so that the Western Railroad could have a direct connection with the city proper. This bridge was erected upon the site of the old "Permanent Bridge," and was so built that, notwithstanding it was upon one of the most crowded thoroughfares of the city of Philadelphia, yet the travel was not interrupted one day during its construction. Having resigned the surveyorship of Philadelphia in eighteen hundred and fifty-three, Mr. Kneass commenced the surveys and location of the Franklin and Warren Railroad in Ohio, in charge of which he remained but a short time, as in eighteen hundred and fifty-four he was appointed Chief Engineer of the North Western Railroad of Pennsylvania, extending from the Pennsylvania Railroad, at Blairsville, northwest, to the Cleveland and Mahoning Railroad. This position he held at the time of his decease, which took place in Philadelphia in February, eighteen hundred and fifty-eight. In professional acquirements Mr. Kneass held an enviable position among American Engineers, which, combined with his social qualities as a man and friend, has endowed his memory with a reputation at once honorable and enduring.





John Chiles

CAPTAIN JOHN CHILDE,

CIVIL ENGINEER.

JOHN CHILDE was born in West Boyleston, Mass., August thirtieth, eighteen hundred and two. He was the son of Zachariah Childe, and one of a family of twelve children. His father, a soldier of the Revolution, was an earnest advocate of liberty and equal rights, was high-spirited, courteous, and kind to his friends, and hospitable to strangers. The poor and needy never went unrefreshed from his door. He had a strong affection for his children, and was especially proud of his boys. To see them rise in the world and become good and useful citizens was his highest happiness. He was the son of David Childe, one of the earliest settlers in the neighborhood, who owned a large tract of land, on which he lived, and where Zachariah was born.

His mother was the daughter of David Bigelow, of Worcester, Mass., and niece of Colonel Timothy Bigelow, of Revolutionary memory. She was a woman of superior intellectual gifts, improved by education and extensive reading. She had a womanly heart, full of tenderness and devotion to her children, and ambitious for their highest good.

During his boyhood, John worked upon his father's farm. His early educational advantages were those of the district school, with the exception of two years spent with an elder brother in Canada, and one year of preparation at Georgetown College, D. C. In his youth he was remarkably studious. He was full to overflowing of boyish spirit, fond of all manly sports, full of affection and tender consideration for those around him, and self-denying for those he loved, in a remarkable degree.

July first, eighteen hundred and twenty-three, he entered West Point Academy. The official report says he excelled in Mathematics, Natural Philosophy, Chemistry, Mineralogy, Engineering, Drawing and Tactics. He was appointed, July first, eighteen hundred and twenty-seven, Second Lieutenant of the Third Artillery. After the usual short leave of absence given to all graduates, he was placed on duty at the Artillery School of Practice, at Fortress Monroe, Virginia, then commanded by Colonel, afterwards Brigadier-General, A. Eustis.

Shortly after his arrival there, the commanding officer, desiring a complete plan of the fortifications made, selected Lieutenant Childe to prepare the drawings, which he executed satisfactorily. He continued on this duty, and those connected with his position as an officer of Artillery at the School of Practice, until selected for Ordnance duty in December, eighteen hundred and twenty-eight. He was then assigned to the United States Arsenal, at Washington City, and remained on duty at that station until November, eighteen hundred and thirty, when he was selected to make drawings of the public buildings and

machinery at the United States Armory at Springfield. Remaining there until December, eighteen hundred and thirty-one, he again returned to his previous station at the Washington Arsenal. In addition to his regular duties, he was, in November, eighteen hundred and thirty-two, appointed to discharge those of Assistant Inspector of Ordnance. In this capacity he visited, in company with Major Worth, then Inspector of Ordnance, all the foundries established by the Government, and assisted in the inspection and proof of the ordnance and projectiles, until February, eighteen hundred and thirty-four, when he was ordered to join his regiment, with which he served, at Fort Wolcott, until December, eighteen hundred and thirty-five, when he resigned his commission in the army, to apply his talents and acquirements to civil engineering,—a profession then attracting to its ranks many of the first officers of the army. During his whole career in the military service Lieutenant Childe never failed to acquit himself with credit, and to give satisfaction in whatever duty he was engaged.

Entering his new field of labor, Lieutenant Childe was employed from eighteen hundred and thirty-five to thirty-six as Assistant Engineer on the York and Wrightsville Railroad, and from eighteen hundred and thirty-six to eighteen hundred and forty-four he was in the service of the Western Railroad Company of Massachusetts ; first in the surveys and location of their road between Wilbraham and the State line of New York, under General William Gibbs McNeil, and Major George W. Whistler as Consulting Engineers, and Captain W. H. Swift as Resident

Engineer, and afterwards in the surveys, location, and construction of the Albany and West Stockbridge Railroad, as Resident Engineer, with General McNeil and Major Whistler as Consulting Engineers.

The route between Springfield and Pittsfield crossed the Green Mountain range. At that early period grave doubts were entertained of the practicability of constructing a railroad over this range, to be worked by locomotives. No experiment had then been made in this country of running a line through a district with such formidable obstacles, and he was deemed a bold man who could give promise of success. In their report, the Engineers say : "This six and a half miles, from Chester to Washington Summit, is the most difficult and expensive part of the route. The river is exceedingly crooked and the mountains shut in on both sides, leaving scarcely room for a road, and requiring numerous crossings. The rocky points thrust themselves quite down to the stream, and no alternative is left, except a resort to very objectionable curvatures between these points. The grade here is also very steep, being eighty-two feet per mile."

Captain Childe had the direction of the surveys and location through this district, and he entered upon the work with great professional enthusiasm. A friend who accompanied him in his first reconnoissance, represents him, on winding in among the hills, as swinging his hat and exclaiming, "*This is the place for engineering.*" After great labor and industry he accomplished the task assigned him to the entire satisfaction of the Managers of the road.

From eighteen hundred and forty-four to forty-five he was Chief Engineer of the Troy and Albany Railroad, and also Chief Engineer of the Connecticut River Railroad to eighteen hundred and forty-seven.

From eighteen hundred and forty-seven to forty-nine Captain Childe was actively employed as Consulting Engineer by the Connecticut River Railroad Company in their alterations at Hadley Falls, also in the survey of the line between Raleigh, North Carolina, and Camden, one hundred and eighty miles; by the Lehigh and Schuylkill Coal Company and the New Boston Coal Company; by the Cattawissa and Somerville Railroad Company; by the Cincinnati and Hamilton Railroad Company, as to the termination of their line in Cincinnati; by the Buffalo and Niagara Falls Railroad Company, on the proposed extension of the line to Lewiston; and at Zanesville, on the best mode of proceeding with the Ohio Central Railroad. He made also, in eighteen hundred and forty-eight, a survey and report of the Albany and Cohoes Railroad, and in June, of the same year, was Consulting Engineer, with Benjamin H. Latrobe and Jonathan Knight, in the service of the Baltimore and Ohio Railroad Company, on the location of that road over one of the most difficult of the mountain passes beyond Cumberland. He spent a fortnight in the reconnoissance of this pass, and confirmed, with his able and experienced colleague, the location made by Mr. Latrobe the previous year, upon which the road was subsequently built, and operated with success. In eighteen hundred and forty-nine, he was consulted by the Hartford and New Haven Railroad Company, on a tunnel and new depot.

From eighteen hundred and forty-eight to eighteen hundred and fifty-one, Captain Childe was Chief Engineer of the Cleveland, Columbus, and Cincinnati Railroad, Ohio, and this road, of one hundred and thirty-six miles in length, was located and constructed under his supervision, though only a portion of his time was devoted to it.

The connection of Captain Childe with the internal improvements of the Southern States commenced in the autumn of eighteen hundred and forty-eight.

The Mobile and Ohio Railroad Company having organized for the purpose of building a road from Mobile to the mouth of the Ohio river, a distance of about five hundred miles, the Directors determined to place at the head of its Engineering Department the most competent man that could be secured. It was the longest road that had been attempted in the United States at that time; under one management, and running across four different States, through a region where railroads were wholly unknown, many difficulties were anticipated, not only from the nature of the country, but from the inexperience of the inhabitants of everything connected with railroad construction and operation.

The following extract from the report of the Directors at the first annual meeting of the stockholders, held at Mobile, February fifth, eighteen hundred and forty-nine, shows the feelings actuating them in making the appointment of Chief Engineer :

"One of the earliest and most important duties devolving upon the Board, was the selection of a competent engineer, to make a thorough and accurate survey of the

route. Fully impressed with the bearing which this appointment would have upon the prospects of the road, and with the necessity of securing an engineer of the highest character for professional skill, the matter was given in charge of a Committee of three Directors, two of whom immediately proceeded North upon the duties assigned them. They found the best engineering talent everywhere employed, and commanding large salaries upon the various public works in progress in the Northern States, and they experienced much difficulty and delay before they were able to fill the appointment. The Board have less reason to regret this delay, however, as it has enabled the Committee to obtain the services of Captain John Childe, as Chief Engineer of the Company, a gentleman whose high reputation and great and varied experience in railroad construction, qualify him eminently for the work, and command for his reports the highest degree of public confidence."

The appointment was tendered and accepted in September, eighteen hundred and forty-eight, and Captain Childe entered upon the discharge of his duties with characteristic promptness and energy.

Four parties of engineers were placed on the line of the road to make the preliminary surveys, under principal assistants of tried skill and ability, and in December, of this year, Captain Childe himself came upon the route. He first visited the northern terminus, opposite Cairo, from thence to Columbus, and then over the whole line to Mobile, where he made a preliminary report to the Board, on the fifth of January, eighteen hundred and forty-nine.

During the spring and summer of this year the surveys were vigorously prosecuted and brought to completion, and in the autumn ensuing the maps, profiles, and estimates of the entire road were finished.

During the summer, a section, thirty-three miles long at the southern end, extending from Mobile to Citronelle, was located, and the work of construction commenced. Having determined the character and cost of the road, with its general location, the next step was to raise the necessary funds to build it. An unsuccessful application had already been made to Congress for an appropriation of a portion of the unoccupied public lands along the route.

During the session of eighteen hundred and forty-nine and fifty, Captain Childe spent most of the time at Washington, laboring with his usual energy and discretion, and the result was the passage of an act donating about one million acres of land in aid of the Company. This was the *first* of a series of acts of Congress on this subject.

Captain Childe now returned to the line of the road, and, being clothed by the Board of Directors with full powers as General Agent of the Company, as well as Chief Engineer, he commenced a course of successful labor that has seldom been excelled in the annals of American railroad construction.

From one end to the other of its long line, with unflagging energy, did he labor to accomplish the desired end. He organized, placed in the field, and superintended the surveying parties engaged in perfecting the location from Citronelle to the mouth of the Ohio. On horseback he

explored the country tributary to the road, to determine the feasibility of constructing branch lines from sections whose commerce would justify the outlay. He examined the eastern part of the State of Missouri, to ascertain the practicability of continuing the railroad on the west side of the Mississippi river to St. Louis, and the great Northwest.

He directed the classifying and arranging of the lands donated by Congress, and superintended the surveys.

In addition to his professional labors, he canvassed the whole country through which the railroad was to be built, county by county, town by town, and almost house by house, to obtain subscriptions of stock, and to interest the people in the work. He organized a system of subscriptions by the counties through which the road passed, and his efforts were successful in obtaining aid in almost every county along the road. He visited the Legislatures of the States through which the road was located, and obtained valuable privileges from them for the Company.

The Railroad Company having made a large issue of bonds, based upon a mortgage of the road, its franchises, and the lands donated by Congress, Captain Childe, with the President, Sidney Smith, were charged with their negotiation. In pursuance of this object, he went to England in eighteen hundred and fifty-three, and again in eighteen hundred and fifty-five. Though not succeeding in disposing of the bonds to the extent anticipated, Capt. Childe obtained the iron and equipments for about two hundred miles of the lower portion of the road, and for a part of the northern section.

In eighteen hundred and fifty-two, trains commenced running over the finished road to Citronelle, gradually reaching farther into the country, year by year, as the road was extended. In addition to his duties as Chief Engineer and General Agent, Captain Childe acted as General Superintendent of Transportation. The labors which he performed for this road until eighteen hundred and fifty-six, when, owing to a change of the Directors, his professional connection with it terminated, can scarcely be exaggerated.

In eighteen hundred and fifty-two Captain Childe was appointed Chief Engineer of the Tennessee and Alabama Railroad, designed to connect Nashville, the capital of Tennessee, with the Mobile and Ohio Railroad, in Mississippi, about one hundred and fifty miles distant.

He immediately organized an efficient corps of engineers, directed their movements for surveying and locating the line, planned the mode of construction, and had the work commenced upon it at the northern end before the close of this year.

In the spring of eighteen hundred and fifty-three he was appointed Chief Engineer of the Nashville and Cincinnati Railroad. The object of this road was to connect the cities of Nashville, Tenn., and Danville, Ky. From the latter point a railroad was already in progress to Cincinnati. He immediately organized two parties of engineers, had the surveys carefully made, the cost estimated, and on the second day of the following December made a report to the Board of Directors upon the cost of the road,

and the resources of the country through which it would pass.

He took charge of constructing the New Orleans and Ohio Railroad in eighteen hundred and fifty-three, extending as a branch of the Mobile and Ohio, from near the northern boundary of Tennessee to Padueah, at the confluence of the Ohio and Tennessee rivers, organizing their affairs upon a sound basis, and stimulating them to exertions that finally were crowned with success.

In the spring of eighteen hundred and fifty-five he was appointed to report upon two surveys, made by different engineers, for the Edgefield and Kentucky Railroad. It resulted in recommendations and suggestions that were adopted by the Company, and insured the completion of their road.

About the same time the Nashville Chamber of Commerce applied to him for a professional opinion upon the proposed location of the railroad bridge over the Cumberland river at Nashville. His professional connection with the New Orleans and Ohio Railroad ceased in eighteen hundred and fifty-six, and with the Tennessee and Alabama Railroad in June, eighteen hundred and fifty-seven.

In October, eighteen hundred and fifty, he was associated with General Wm. Gibbs McNeil and C. S. Growski, a Civil Engineer of Canada, in examining and making a report upon the most feasible plan for the improvement of the navigation of the river St. Lawrence, particularly at Lake St. Peters. This lake being but eleven feet deep at low water, presented a very serious obstacle to the navigation of the river. To improve this navigation the

Provincial Parliament, as early as eighteen hundred and forty-three, made a grant of money for deepening the channel to fourteen feet at low water, to be done under the direction of the Board of Public Works. They undertook to form an entirely new channel, and in four seasons spent upon it about three hundred thousand dollars, when the Government stopped the work as a complete failure.

Nothing further was done until eighteen hundred and forty, when, by the procurement of the Hon. John Young, the Board of Harbor Commissioners of Montreal were authorized to undertake the work, and Mr. Young was appointed upon the Commission. The first step taken at his suggestion was to appoint the above Board of Engineers, to report upon the best course to be pursued to obtain a ship canal, sixteen feet in depth at low water.

After a careful examination and survey, the Board of Engineers made a report, recommending the abandonment of the work done on the new channel, and the excavation of the old one to sixteen feet in depth and forty-five feet in width.

The recommendation to abandon a work upon which the Government had expended such a large sum of money met with much opposition, and the business community were for a time divided in opinion on the subject. The plan was, however, adopted by the Harbor Commissioners, and with complete success in the result.

When, in eighteen hundred and fifty-seven, the Board of Harbor Commissioners was established for constructing an extensive harbor at Montreal, Captain Childe was employed and authorized to organize a corps of engineers

to make the necessary examinations for this work and report thereon to the Commissioners. This enterprise contemplated a very large expenditure in money, and its execution required superior engineering talent. Captain Childe was placed at the head of the corps, and Messrs. William J. McAlpine and James P. Kirkwood were associated with him. He devoted himself with great assiduity and industry to the preliminary surveys, plans, and estimates for the extensive masonry and other work required. In preparing a report for the Commissioners, he maintained an extensive correspondence, gathering the statistics of trade which would be affected by the harbor, or have an influence in recommending its construction. He had collected a large amount of statistical information relating more particularly to the commerce of the St. Lawrence and to Canada, and, while occupied in arranging these materials for the official report, which he was designated to prepare, together with the necessary maps and drawings, he was suddenly prostrated by illness, which terminated his life, on the second day of February, eighteen hundred and fifty-eight.*

To a lover of nature, to one who is fond of adventure, and finds real companionship in the solitude of forests, the profession of a Civil Engineer has a peculiar attraction, free as it is, alike from the trammels of social

* Captain Childe, during his professional career, was the inventor of many mechanical improvements, the most prominent of which are: the Hoisting Machinery at Greenbush depot, opposite Albany, for transferring freight from cars to boats, and *vice versa*; the Variable Cut-off for locomotive engines, and the Extended Fire-box for locomotives.

etiquette, and the monotony which attaches to almost every profession connected with city life.

Captain Childe's enthusiasm for the Mobile and Ohio Railroad, and his devotion to it, were like that of the artist for his model of clay, as he looks forward to its glorious resurrection in living marble, or the painter, who, as he adds touch after touch to the canvas, each so little in itself, dreams and warms into enthusiasm as he anticipates the finished landscape which shall rouse the beholder to a fresher appreciation of the glories of nature.

No doubt, to the uninitiated an absorbing enthusiasm for a railroad seems improbable, but to one like Captain Childe, a railroad is endowed with a personal and moral power, inculcating patriotism, lessening sectional prejudices, and binding together, by social and commercial interests, North and South, East and West.

He looked forward to the day, when the road being finished, its passing trains should, as a shuttle, weave into closer bonds the commercial interests of the whole valley of the Mississippi, from the Northern Lakes to the Gulf of Mexico.

Such were the sentiments, and such the spirit, in which Capt. Childe labored.

The character of Captain Childe, whether it be regarded from a professional or personal point of view, was not an ordinary one. That his industry was incessant, and his power of executing the most elaborate work unusually great, it is only necessary to peruse this outline of his professional labors, to understand. In reference to his great professional work on the Mobile and Ohio Railroad, a

friend, who was a witness of his efforts, says: "These labors cannot easily be so described as to give any correct idea of what annoyance and vexation he met with. To plan the road, to induce the public to sustain it, to smooth asperities, to supervise, and to be the fiscal agent also, left his mind and body but little repose. Those employed by him, no matter how or where, had a ready compliance with his requirements, arising from his just and impartial character."

In connection with another road, a friend writes of him: "I had constant opportunities to admire his sound judgment, his resolute, laborious, and self-sacrificing fidelity, and the modest firmness and dignity with which he maintained his position on disputed questions of theory and practice. His official reports were models for logical force and accuracy, and for remarkable terseness and clearness of statement, and were generally conclusive in the matters they discussed. They also exhibited a trait of character, which gave to all his representations hardly less weight than the reasons he urged. I refer to his unswerving integrity and fearless independence. All who knew him or heard him felt that his loyalty to truth was so uncompromising that he never spoke without uttering his honest thought, irrespective of persons, place, or policy, and regardless alike of whom it might please or displease, and of its effect on himself or others."

With a mind of undeviating honesty and unflinching integrity, severe in his requirements of himself, but gentle as a woman in his judgment of others, he combined a tenderness for the weak, the erring, and the ignorant, as rare

as it is beautiful to see. With a mind which he himself said grew strong with opposition and obstacles, he had yet a ready sympathy to help upward and onward all who appealed to him. Few persons, in proportion to their means, have given more to others. His private papers are a noble record of generous deeds.

He fully embodied the ideal of the Christian gentleman. His courtesy was a marked feature, and was never laid aside, because it was nothing assumed, but the natural outgrowth of his manly, generous, and deeply religious nature. He was an ardent lover of nature. A friend once said of him : "It seems to me not a cloud passes over his head, not a bud blossoms, not a tree waves in the sunlight, but brings him a real pleasure. The rising and setting sun, the moonlight and the starlight, are fresher enjoyments to him than to any one I have ever known. Each morning seemed to rouse him naturally to grateful devotions ; and he often remarked, 'That nature did all things gently and gradually,' and he used the dawning of day as one of the many reproofs nature offers to man for his reckless haste in bringing about his own wishes and purposes."

He often expressed himself thus : "When I feel that I have exhausted the capacities for enjoyment of a single day, I may entertain the idea of being weary of this life. It is a glorious world ! and there is so much to do in it!"

He was a member of the Unitarian Church, and, both in his private and public life, he walked worthily of his profession of a follower of Christ. He was specially fond of devotional exercises, both private and public.

In all the relations of social life he was genial and sympathetic in a high degree, and in addition to that influence over others which truly cultivated and spiritually minded men usually have, he possessed in a large measure what might be termed a magnetic personal attraction.

His fine, erect figure, and martial bearing, and his strikingly intellectual countenance impressed even those who casually met him. He was eminently gifted in conversation, and in that rare power of imparting knowledge to others, which gave to his companionship a peculiar charm and value.

In his friendships there was a singular character of tenacity and devotion. As husband and father, he was all the Christian should be—anxious for the welfare of those he loved with deepest devotion, never sparing himself for one moment in anything that could contribute to their pleasure or happiness.

To his keen appreciation of the beauty of the world around him was added a full enjoyment of the minor pleasures of the fireside, and the seemingly grave man, full of plans, minute calculations, and weighty duties, was always ready to frolic with children, and to join in all the pleasures of the home circle. His manner was singularly calm and self-possessed, and gave an impression of purity of heart, which was a silent rebuke to every unworthy word or deed, and seemed to throw an exalting influence upon all around him.

In eighteen hundred and thirty-two Captain Childe married Laura, daughter of James S. Dwight, of Springfield, Mass. Their only son died in eighteen hundred and

thirty-eight. Mrs. Childe, and the oldest daughter, aged nineteen years, were lost on board the ill-fated Arctic, while returning from Europe.

In eighteen hundred and fifty-six he married Ellen W., daughter of Mark Healy, of Boston. He died at his home in Springfield, leaving a widow, daughter, and son, and was buried in the Springfield Cemetery, where a monument is erected to his memory.

FREDERICK HARBACH,

CIVIL ENGINEER.

FREDERICK HARBACH, the fourth child of Thomas and Nancy Harbach, was born in the town of Sutton, Worcester County, Massachusetts, the twenty-ninth day of April, eighteen hundred and seventeen. His father was a woollen manufacturer. Frederick, at his thirteenth year, had received only the education afforded by a common district school, but at this period the removal of his father to Worcester afforded him the advantages of the excellent schools of that city. From early childhood he manifested that ingenuity, decision, and indomitable perseverance, which were through life his special characteristics.

From infancy Frederick suffered from some malady of the heart, and active exercise would cause violent palpitations, accompanied by bleeding of the nose, and although this weakness unsuited him for manual labor, he never pleaded sickness as an excuse for the avoidance of duty, and very rarely, even when a child, mentioned to any one the pain he suffered.

At an early period he displayed great fondness for machinery, spending most of his leisure hours in visiting factories and machine shops, and was often engaged in

fashioning some toy engine or invention of his own. Railroad construction soon attracted his attention.

In the spring of eighteen hundred and thirty-six he obtained the situation of chain-man under the late Herman Stebbins, C. E., and was engaged upon the surveys and location of the railroad from Springfield to Albany, at a salary of sixteen dollars per month. Later, Mr. Stebbins was placed in charge of the construction of the third division of this work, and held this position till his death in the fall of eighteen hundred and thirty-eight. Mr. Harbach was then promoted to the place thus made vacant, and successfully completed the division in the latter part of eighteen hundred and thirty-nine.

In July, eighteen hundred and forty, he was appointed Assistant Engineer on the Albany and West Stockbridge Railroad, under Captain John Childe. His execution of the work of this division added to his growing reputation. In June, eighteen hundred and forty-three, he was called to the Hartford and Springfield Railroad, and remained upon it as Chief Engineer, until its completion in the spring of eighteen hundred and forty-five. The same year he was appointed Chief Engineer of the Pittsfield and North Adams Railroad, and remained in charge until its completion in eighteen hundred and forty-seven. The thorough and economical construction of this work established for him a high professional reputation.

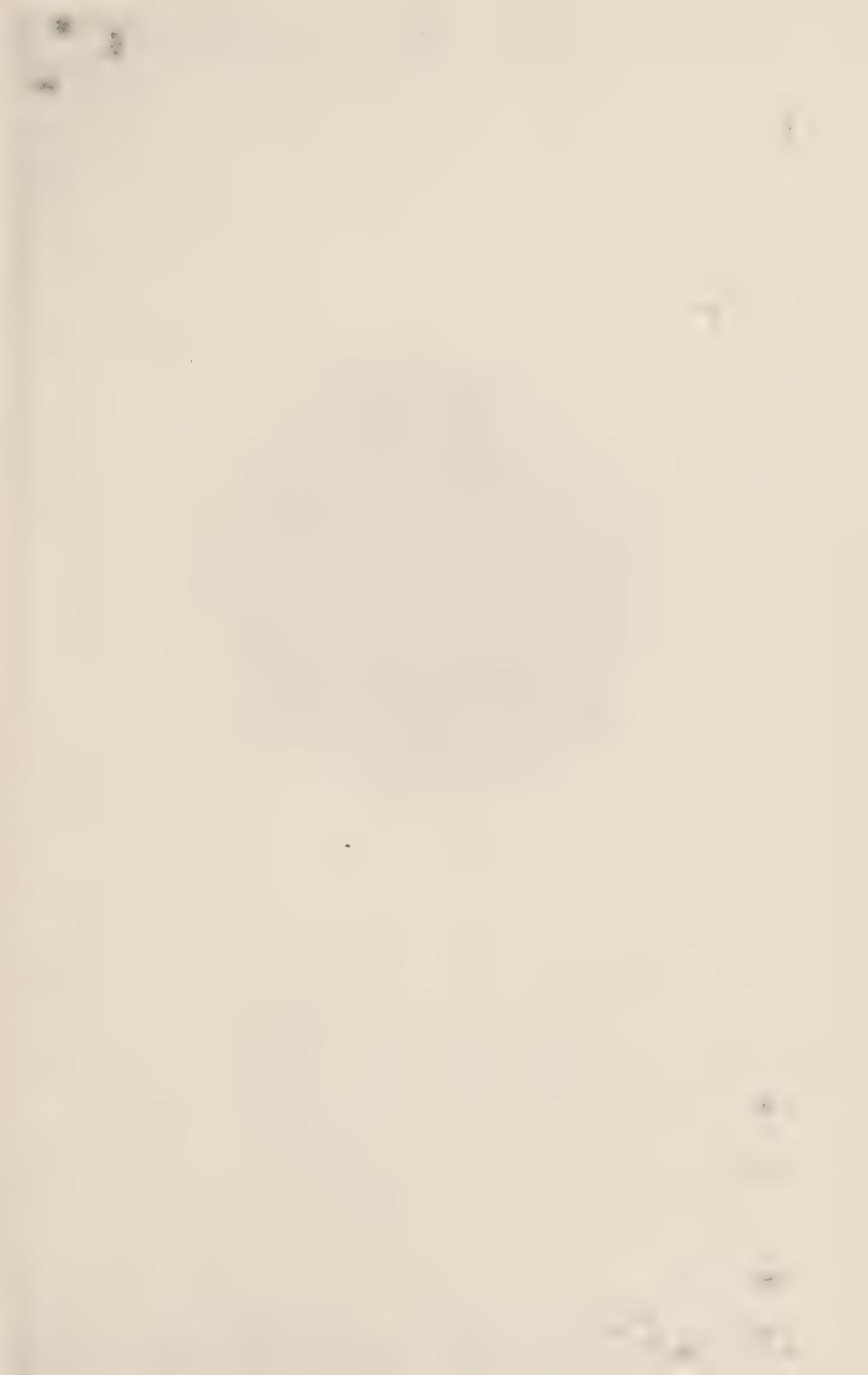
He purchased, in eighteen hundred and forty-seven, an interest in Gordon McKay's machine shop, at Pittsfield, Mass., and entered into engagements with parties to start a woollen factory in the same town ; but shortly after dis-

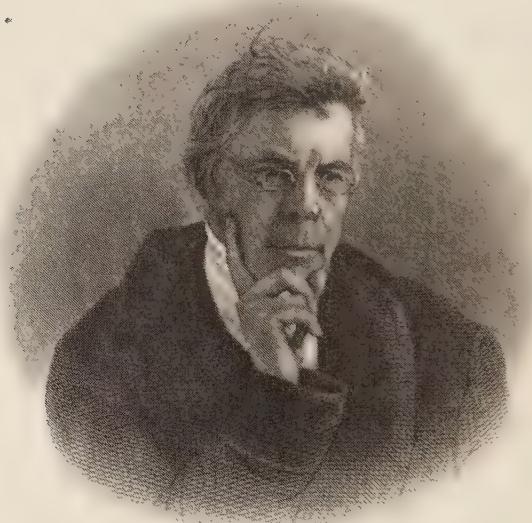
posed of his interests and accepted an appointment upon the Cleveland, Columbus and Cincinnati Railroad, under Captain John Childe, Chief Engineer, and made the preliminary surveys of that railroad. In the spring of eighteen hundred and forty-eight, he formed a partnership with Amasa Stone, Jr., and Stillman Witt, and executed a contract to build, and equip, entire (except the iron), the Cleveland, Columbus and Cincinnati Railroad. This was successfully accomplished, Mr. Harbach, with his indefatigable energy pushing forward all parts of the great undertaking. At the same time he was Chief Engineer of the Michigan Southern and Northern Indiana Railroad, carrying that enterprise along with equal vigor. Scarcely was the Cleveland, Columbus and Cincinnati Railroad completed, when Messrs. Harbach, Stone and Witt contracted to build the Cleveland, Painesville and Ashtabula Railroad, and, in his own name, contracting to execute the work of the Pennsylvania section of the road, twenty-five miles in length.

With all the responsibilities attending the construction of five hundred miles of railroad, he found time to invent and procure Letters Patent for a rotary dumping car, for a saw to cut off pile heads under water, for a safety switch, for an improvement in steam saw-mills, for car wheels, for an iron railroad bridge, and for a coal-burning locomotive engine. In the purchase and improvement of Western real estate, he was likewise largely interested.

But his labors and unremitting application told heavily on a constitution naturally weak. The old malady of the heart was doing its fatal work, and at the Astor House,

New York, where he had gone on business, he breathed his last, on the thirteenth day of February, eighteen hundred and fifty-one. With his genius still culminating and his brain yet teeming with broad ideas of commercial progress and brilliant creations for that great civilizer, the railroad ; with riches at his command, and with a princely fortune gathering in the train of his gigantic projects, thus died the foremost of the young engineers of America.





Yours very truly
J. B. Douglass

MAJOR DAVID BATES DOUGLASS,

CIVIL AND MILITARY ENGINEER.

DAVID BATES DOUGLASS, son of Nathaniel and Sarah Bates Douglass, was born at Pompton, New Jersey, March twenty-first, seventeen hundred and ninety. His mother, a woman of superior mind, was a sister of David S. Bates, a distinguished engineer, whose memoir is contained in this volume.

Mrs. Douglass superintended personally the education of her son, carefully directing his studies until his entrance at Yale College, from which he graduated with high honors in September, eighteen hundred and thirteen.

Young Douglass directed his steps immediately from Yale to the Military Academy at West Point, where he made application to General Joseph G. Swift, for an appointment in the Engineer Corps of the United States Army, and received from him a recommendation to the Secretary of War, then engaged at Sackett's Harbor. His journey to that place, and the result of his application, is told in the following extracts from a letter to Professor Olmstead, of Yale College, under date of October, eighteen hundred and forty-three :

“ We took our degrees, I remember, on the eighteenth

of September. On the first of October I was an officer of Engineers in the United States Army. My determination had been previously formed, and I travelled alone and almost unaided to Sackett's Harbor to prefer my application. Men of education were in great request for that department of service, and I was commissioned in ten minutes after presenting myself. Could you realize the discouragements of that journey through woods and over *corde-du-roi* roads, or sinking in the swamps at that season of the year, you would better imagine the happiness of the moment which crowned my perseverance with such success. I returned immediately to West Point to prepare for the next year's campaign, and there found myself a few weeks after, the commander of a corps of Sappers and Miners, and presently commander of the post. These were to me, then, very novel responsibilities. I mention them not vauntingly, but for the moral they contain ; they compelled me to take position, to assume responsibility, and to sustain myself in both ; to the habit of doing this is owing whatever of usefulness I may have achieved in all my subsequent life."

In eighteen hundred and fourteen he was detailed with his command in the North-western campaign of that year. To Professor Olmstead he wrote : "The whole campaign was a rapid series of occasions requiring the greatest promptness and energy. The bayonets of a numerous hostile foe were glittering in plain sight when I joined the division. The battle of Lundy's Lane occurred only twelve days after, and was followed by the siege of Fort Erie, where a series of sharp encounters and an unceasing

cannonade was sustained for about six weeks, when the memorable sortie broke up the enemy's line and compelled him to retire."

During this siege, the little army at Fort Erie, pressed by the reinforcements of General Drummond, was saved from annihilation by the intrenchments which were built by this youthful officer, who, to use his own words, "was there day and night, regardless of rest and shelter, to superintend and direct them. The working parties were relieved, but myself never." By this means the army was covered with defensible intrenchments in less time than was ever before known. On the fifteenth of August the attack was made by the reinforced enemy, under cover of night, in three strong columns, of which the centre one, moving upon Fort Erie proper, succeeded in gaining a footing in the salient bastion of that work. The interior arrangements fortunately prevented further penetration, and the assailants were dislodged. But, had the left column which attacked the "Douglass Battery" and the intrenchments of the extreme right succeeded, Fort Erie must have been lost. No interior works were there to prevent the enemy's progress. Had he entered, the centre column would have been enabled to take advantage of the position ; it was strongly organized under an experienced commander, and did not cease its assaults until its effective strength had been reduced from seven hundred and fifty men to less than two hundred, and the commander slain.

General Gaines, writing upon this event in eighteen hundred and fifteen, remarks :

" Among the many brilliant scenes which combined to

dispel the clouds and darkness, and brighten the dawn of that memorable morning, the defence of the ' Douglass Battery ' stands equalled by few, and, according to the relative number of guns, surpassed by none. The youthful commander of that battery excited my admiration. His constancy and courage during a brisk cannonade and bombardment of several weeks, often in the night as well as in the day, his gallantry and good conduct in the defence against a vigorous assault by a vast superiority of numbers, are incidents which can never cease to be cherished in my memory as among the most heroic and pleasing I have ever witnessed."

For his brilliant services upon this occasion Lieutenant Douglass was promoted Captain by brevet, and in eighteen hundred and fifteen was detailed for duty with the army then organizing against Castine, when the proclamation of peace changed his destination. He returned to West Point, and in the same year married Miss Anna E. Ellicott, daughter of Major Andrew Ellicott, who was then Professor of Mathematics at the Academy.

In April of this year Captain Douglass was ordered by General Joseph G. Swift to repair to the States of Connecticut and Rhode Island to examine the condition of the fortifications in the harbors of New Haven, New London, Stonington, and Newport. Subsequently to this, Captain Douglass received the appointment of Assistant Professor of Natural Philosophy in the Military Academy. The succeeding fifteen years of Professor Douglass's life were occupied in active official duties at West Point and in civil engineering.

In eighteen hundred and seventeen he received instructions from General Swift to make a reconnoissance of the eastern entrance to Long Island Sound, with a view to the construction of fortifications.

By a resolution of the Board of Canal Commissioners of Pennsylvania, Major Douglass was called upon to make surveys and estimates for a canal from Conneaut Lake to Lake Erie and the French Creek feeder, in accordance with an Act of the Legislature of that State, passed in February, eighteen hundred and twenty-six. This work was completed to the satisfaction of the Board of Commissioners, and in June, eighteen hundred and twenty-seven, he was appointed by the same Board to survey the line of canal to Lake Erie, and in the summer of the following year was employed upon the surveys and location of the Upper Delaware Canal. Upon the completion of this work, in April, eighteen hundred and twenty-seven, he was appointed by the Sandy and Beaver Canal Company of Ohio to revise the surveys for that work, which was performed, under his instruction, by Mr. J. Mahlin, as Engineer. Major Douglass also accepted an appointment from the Board of Commissioners of Internal Improvements of Pennsylvania to make surveys and examinations in the vicinity of Philadelphia, with a view to design the most advantageous terminus for the Pennsylvania Railroad.

In November, eighteen hundred and twenty-eight, Major Douglass received an invitation from Hon. C. D. Colden, to accompany a corps of engineers along the line of the Morris Canal (New Jersey), with a view of obtain-

ing an opinion relative to the use of inclined planes in the place of locks on the contemplated improvement.

This question had been agitated many years, and, as early as eighteen hundred and twenty-three, letters were exchanged between Governor De Witt Clinton and Major Douglass relative to their practicability upon the Morris Canal.

Having devoted much attention to the subject, he gave his views, and the preference of the Board for his plan resulted in a proposition that he should take charge of the construction of the work, to which he replied: "Having duly considered the request made by you, in behalf of the Morris Canal Company, that I should undertake the special direction and management of the inclined planes on the line of canal, as Chief Engineer of the same, and in view of the explanations which have passed between us on this subject, I beg leave to submit the proposition enclosed as a basis of an arrangement under which I will cheerfully comply with your request, provided I can obtain the necessary dispensation from my public duties in the Military Academy."

The proposition was cheerfully acceded to by the Board, and a resolution passed to appoint Major Douglass Chief Engineer at a compensation of four thousand dollars per annum.

The petition of Major Douglass for a furlough was twice refused by the Secretary of War, but the unwillingness of the Canal Company to relinquish their claim upon his services, induced him to make an effort to carry forward the work with the aid of a Resident Engineer, if it should be

deemed practicable. With this design, he appealed in March, eighteen hundred and thirty, to the Department for a furlough, as follows :

“ A necessity, which I find impossible to avoid without dishonor, compels me to ask leave of absence from my duties in the Military Academy for the term of four weeks, commencing on the twenty-fifth of the present month. An arrangement has been made for the performance of my duties during that time, and as the class has nearly completed its studies for this year, it is believed no material inconvenience will result to my pupils in consequence of my absence.

“ I was induced in September last to make an engagement for services upon which heavy responsibilities depend, and from which I could not afterward, and cannot now, honorably retract. The strict performance of this engagement would require me, situated as I now am, to relinquish my position in the public service altogether ; but as I am not prepared to act upon this question, thus suddenly and unexpectedly forced upon me, I submit the present application as my only alternative.”

A furlough was granted, and Major Douglass immediately gave his personal attention to the work. In a letter from one of the Directors, Major Douglass was thus advised :

“ You are authorized by the Board to proceed forthwith to the completion of one of the two planes at Montville. You know we have had several Plane Engineers, and must expect some tenacity of opinion in the several projectors. But your drawings, models, and explanations

will doubtless be effectual for this purpose, and inspire more confidence. I pray you proceed at once, and have the work completed before the river opens."

Major Douglass, finding his personal attention indispensable to the successful completion of the inclined planes, relinquished his position in the public service in the autumn of eighteen hundred and thirty, his resignation to take effect the first of March, eighteen hundred and thirty-one.* In a letter to General Gratiot he thus explained his position :

"It is known to the Department that I have become connected with the Morris Canal Company, for the purpose of bringing inclined planes into effective operation in lieu of locks for canal navigation. I have become in some degree identified with this improvement, and as it is one of great importance in civil engineering, I have thought it due to myself as well as to the Company that I should give it my whole time and attention. I would gladly have accomplished this object as an officer of the United States, but as this seems incompatible with my engagement in the Military Academy, I have no alternative but to relinquish my station entirely. This, and not the offer of higher pay, as stated by the Board of Visitors, is the occasion of my resignation."

Major Douglass directed his efforts to the completion of one of the Montville "planes," in the autumn of eighteen hundred and thirty. The inclined plane proved a success;

* Major Douglass was Professor of "Mathematics" from August twenty-ninth, eighteen hundred and twenty, to May first, eighteen hundred and twenty-three, and Professor of "Civil and Military Engineering" from May first, eighteen hundred and twenty-three, to March first, eighteen hundred and thirty-one.

Major Douglass received the congratulations of the Board, with a copy of the following report, under date of October twenty-fifth, eighteen hundred and thirty :

“ The Committee of Directors appointed by the Board to witness a trial of the inclined plane at Montville, beg leave to report that on Saturday last they visited and inspected the said “ plane,” and witnessed the passage of a loaded boat up and down the incline, and into the level at its head and foot. The Committee being satisfied with the operation of the machinery, and the solidity as well as the durability of the whole work, and feeling confident that it will realize in practice the most sanguine expectations, beg to offer their congratulations to the Board upon the happy result of the experiment.”

The “ Newark Eagle ” thus describes this opening of the work : “ The machinery was set in motion under the direction of Major Douglass, the enterprising Engineer. The boat, with two hundred persons on board, rose majestically out of the water ; in one minute it was upon the summit, which it passed apparently with all the ease that a ship would cross a wave of the sea. As the forward wheels of the car commenced their descent, the boat seemed gently to bow to the spectators and the town below, then glided quickly down the wooden way. In six minutes and thirty seconds it descended from the summit and re-entered the canal, thus passing a plane one thousand and forty feet long, with a descent of seventy feet, and advancing seven hundred and seventy feet, in six and one half minutes.”

In conjunction with his duties upon the Morris Canal,

which was completed and ready for the opening of navigation in the spring of eighteen hundred and thirty-two, Major Douglass made a reconnoissance to ascertain the practicability of uniting the city of Pittsburgh with the Ohio Canal by railroad. The Philadelphia, Germantown and Norristown Railroad also occupied a portion of his attention.

In eighteen hundred and thirty-two he entered the New York University, its first Professor of Natural Philosophy; but, finding his Professorship to interfere with his engineering pursuits, he relinquished this position after one year's duty, but was borne on the roll of the Institution as Professor of Civil Engineering and Architecture, and, during the years of eighteen hundred and thirty-six and thirty-seven, delivered a course of eighty lectures on these subjects.

In eighteen hundred and thirty-three he was called upon to survey the route for the Brooklyn and Jamaica Railroad on Long Island, which he completed in the winter of that year.

An Act was passed by the New York Legislature, February, eighteen hundred and thirty-three, authorizing surveys and estimates for supplying the city of New York with water. Immediately after the passage of this Act, the Board of Water Commissioners appointed Major Douglass and Canvass White, Engineers. But the professional duties of Mr. White in the State of New Jersey preventing him from making the examinations desired by the Commissioners, the whole duty devolved upon Major Douglass, who completed the preliminary surveys, in

November of that year, and made his report soon thereafter ; regarding which the Commissioners, in their report of November, eighteen hundred and thirty-three, say :

“ For a more particular and detailed description of the surveys and other important information on the subject, the Commissioners beg leave to refer to the able and lucid report of the Engineer, Major D. B. Douglass, hereunto annexed.”

In the report referred to, Major Douglass recommended the use of the Croton river and its tributaries, to be conveyed to the city by an enclosed stone aqueduct, and estimated the length of the same from the confluence to the Receiving Reservoir at Manhattanville, at thirty-seven miles, and from the latter to the Distributing Reservoir, five and one half miles. The report states that “ the structure of masonry has been adopted instead of iron pipes, on the ground of its superiority in point of economy, durability and efficiency.” Also, “ the crossing of the Harlem river is proposed to be effected by means of an aqueduct bridge, eleven hundred and eighty feet long from abutment to abutment, consisting of nine semi-circular arches. The height of the structure, from the water-line of the river to the water-line of the aqueduct, would be one hundred and twenty-six feet, exclusive of the hydraulic foundations, which would be from ten to twenty feet more. A structure adapted to these dimensions would, of course, be a work of considerable labor and expense, but by no means of paramount difficulty in either respects.”

A feasible and durable plan for supplying the city of New York with pure water in abundance for not only its

population at the time, but for the anticipated rapid increase in the future, had, since the year eighteen hundred and twenty, agitated the public mind, and various methods had been devised, and plans reported upon, none of which to this period, proved acceptable to the citizens.

Major Douglass at once comprehended the importance of the undertaking, both as to the health and its bearing upon the future growth of the city, and earnestly devoted himself to the successful accomplishment of the work.

The first investigations were directed to finding an abundant and unfailing supply of pure, wholesome water, and at an elevation that would allow of its flow into the city by its own gravitation, and with a head that would supply the upper stories of the buildings, and that could be used from the hydrant for the extinguishment of fires.

With these purposes in view Major Douglass commenced his explorations and surveys in May, eighteen hundred and thirty-three, and in the following month he reported examinations of "all the chief tributaries of the Croton river and several of the remarkable reservoirs from which they derive their supply ; generalizing meanwhile the slope of the left bank with reference to the various routes of exit in the direction of the city. This is indeed a wonderful country for water, whether we regard the abundance or the purity of its fountains ; and the intervening obstacles appear less formidable than I had supposed them to be."

On the completion of the preliminary surveys and an estimate of cost, Major Douglass submitted a report to

the Board of Commissioners, and the feasibility of the plan was so clearly shown, that the sanction of the Legislature was readily obtained in an Act of May, eighteen hundred and thirty-four, for proceeding with the construction of the work. Douglass was appointed by the Commissioners Chief Engineer.

As early as October, eighteen hundred and thirty-five, the surveys necessary for the location of the Croton Dam were completed, but, in opposition to the judgment of the Chief Engineer, the Commissioners changed the location to Garretson's Mill, with a graduation of forty feet as its height.

Throughout his term of service Major Douglass found great difficulty in maintaining proper discipline in his corps of engineers, from the limited power with which the Commissioners invested him. They were unwilling to admit the necessity of an Engineering Department, and while Major Douglass fully realized the magnitude of the undertaking, the Board regarded it as little more than an extended job of plain masonry, that might easily be constructed upon very economical principles.

There existed widely different views of economy and discipline between the first Board of Commissioners and the Chief Engineer, which finally led to a change that was universally regretted by the numerous friends of Major Douglass. In October, eighteen hundred and thirty-six, he was removed from the charge which his experience and high scientific attainments so ably qualified him to prosecute to completion. His surveys, plans, drawings and reports were submitted to the Board, and by them

adopted, and the construction of the work passed into other hands.

The various surmises and rumors consequent upon the abrupt and unexpected discharge of Major Douglass by the Board of Commissioners, in many instances prejudicial to his reputation, and from which he would not undertake to exonerate himself, although urged by several members of the Board to do so, is fully explained in the following letter to one of the Commissioners, in eighteen hundred and forty :

"In addressing a few lines to you on the subject of the unpleasant controversy which occurred in eighteen hundred and thirty-five and six, I cannot think it will be necessary to say much in the way of vindicating myself. You did not indeed witness but a very small portion of the violence and overbearing of Mr. Allen's conduct to me, but enough must have been seen to assure you that it was wholly as involuntary as it certainly was free from personality on my part. Should you have any doubts on this point, they cannot but be removed when I assure you that painful as the controversy was in itself, and disastrous as the consequences have been to me to be thus thrown out of employment suddenly and unexpectedly, at a time when all other resources were unavailable; to have a great work, the only one which I had thought worthy of my ambition, taken out of my hands after being matured in all its most difficult features; my professional character—the capital on which I and many others depend for our daily bread—assailed,—to have experienced all this at the hands of Mr. Allen, while my friends were importuning me to write,

and members of the Common Council urging me to furnish statements, yet I resisted all influences, and published not a line.

"It would have been very easy to show the unsoundness of every allegation brought against me, either in the Commissioners, report or in the papers, from eighteen hundred and thirty-five to the present time. I pledge myself to do this for you, or for the new Board, whenever you or they may desire it; but I abstain from doing it before the public, simply because I resolved that no consideration of a personal kind should induce me to do anything to disturb or interrupt the progress of the great work. Let me beg you to consider the exceeding injustice of the assertion often made by Mr. Alleys and Mr. Allen, that I had been a partisan in opposition to the Water Commissioners. Had I been such a partisan these gentlemen would have heard from me in different style, but I have not been."

In eighteen hundred and thirty-seven and thirty-eight Major Douglass made an examination and report on the hydraulic power of the Monmouth Purchase, also a reconnaissance of the coal region of the Upper Potomac, and from eighteen hundred and thirty-seven to eighteen hundred and forty, he was occupied in laying out the grounds of Greenwood Cemetery. This beautiful locality was observed by him as highly appropriate to such a purpose while engaged in the construction of the Brooklyn and Jamaica Railroad. These surveys, although they had no reference originally to this object, were incidentally applied to it in public lectures, which he was called upon to deliver

in Brooklyn, about the period of eighteen hundred and thirty-five. The original cemetery comprised only one hundred and seventy-eight acres, the ground declining in some places to valleys of less than twenty feet above tide water, and in others rising to hills of more than two hundred feet. Mount Washington is two hundred and sixteen feet, being the most elevated ground in Kings County, and one of the highest points on Long Island. A heavy native growth of fine old forest trees suggested the name of "Greenwood" as appropriate for this cemetery. The artistic skill and classic taste of Major Douglass is beautifully illustrated in the laying out of this quiet and romantic home for the dead.

It contains four hundred and thirteen acres of hill and dale. Mount Auburn is beautiful, Laurel Hill has its charms, but none of the cemeteries of the country can compare with Greenwood in the wonderful grandeur of its views, its variety of landscape, and its extent. The avenues extend for nearly twenty-five miles, and it has several hundred miles of walks and paths within its enclosure.

From eighteen hundred and thirty-nine about five million dollars have been received, and nearly all of it expended on improvements. To grade the grounds, and lay out the avenues and walks, was an immense work, and it has continued through many years, not being entirely completed even now.

The principal entrance to Greenwood is on Fifth avenue, South Brooklyn; the gateway is a magnificent and costly structure of Gothic form, and constructed of the finest brown sandstone. It is very large, and presents an im-

posing and massive appearance. This gateway is probably the finest piece of architecture of its kind in this country.

In his letter of resignation to the Board of Trustees of Greenwood Cemetery, of which he was President, tendered in January, eighteen hundred and forty-one, Major Douglass remarked : "The local organization and the laying out of the grounds is now essentially completed. To have left this in an imperfect or unfinished state would have incurred the loss of much previous labor. I have felt it imperative, therefore, to remain in office at all hazards until it was finished. It has been a work of much greater labor than I supposed when I commenced it. The extent as well as the varied features of the ground have called for long-continued, oft-repeated, and very careful study ; and this I have given it, but with what effect cannot be seen until the design shall have been in some degree carried out by the opening of the avenues."

The immediate cause of Major Douglass's resignation was his acceptance of a call to the Presidency of Kenyon College, in Ohio. Before leaving for his new charge, he submitted the plans and drawings for the improvement of the cemetery grounds to the Board. Mr. J. A. Perry, of Brooklyn, writing to him upon the subject a year subsequently, observed :

" Anything about Greenwood, and especially its long desired success, would not be an uninteresting theme to its old and faithful friend. We are now opening our avenues through the forests, and they open most beautifully. Having, providentially it would seem, nothing to occupy my time since March last, I have devoted it all to Green-

wood, and delightful work, now that it is crowned with success, has it been. In June we propose to consecrate our grounds. It is but meet that one who has contributed so greatly to the establishment, and developed so admirably the beauties of Greenwood, as we delight in thinking you have done, should participate in the ceremonies of that occasion. Can you not be with us?" Major Douglass replied as follows :

" Believe me, you could not have done me a greater favor than in thus communicating the future brightness of Greenwood. My own associations with it are as fondly cherished, and all my recollections of it are as fresh as ever. How delighted would I be could I promise myself, with any degree of assurance, the pleasure you hold up to my view so temptingly, of joining with you in the approaching consecration ; but I fear it is impossible.

" I can realize how delightful a relief the Greenwood improvements must be to your mind. Pressed and borne down as I frequently was while there engaged, its associations were always vivifying and gladdening to me. Its deep shades and quiet retreats, its old oaks and green cedars, the umber foliage during its Indian summer, the setting sun from Mount Washington, its breezes and its flocks of birds, every thing about it was unlike any thing else in this world. I yearn to see them again. Indeed, every thing about Brooklyn continues to interest me as much as ever. No lapse of time can efface the smallest of the recollections by which it is endeared to me."

The following letter from Professor Olmstead, of Yale College, to Rev. Malcolm Douglass, indicates the feelings

of those with whom Major Douglass was early associated, and the deep interest his class-mates manifested in his subsequent varied and brilliant career :

“ I send herewith the interesting letter addressed by your honored father to his class-mates at their thirty years’ meeting, in eighteen hundred and forty-three. It was read in the meeting and listened to with lively interest, but with deep regret that the writer could not make one of our most delightful party. Professor Douglass was justly regarded as a member who had done great honor to his class, by his gallantry in the service of his country during the war of eighteen hundred and twelve, and by his eminence as a man of science, particularly by the great public works which he projected, several of which remain as durable monuments of his genius and skill.”

Major Douglass continued his association with Kenyon College until eighteen hundred and forty-four, when he returned to the East and occupied his time until eighteen hundred and forty-eight, in the active discharge of various duties, among which were the planning and laying out of the Albany Rural and of the Quebec Cemeteries, the survey of the Albany Water Works, the drainage and graduation of South Brooklyn, the planning a supporting wall for a portion of Brooklyn Heights, in examinations and reports upon the best method for supplying that city with water, and the laying out of the grounds of the New Brighton Association of Staten Island. In eighteen hundred and forty-eight he was called to the chair of Mathematics at Geneva (now Hobart) College, which he accepted although

other propositions were laid before him with offers of greater compensation.

Major Douglass died at his residence in Geneva, New York, October twenty-first, eighteen hundred and forty-nine, from the effects of a paralytic stroke, at the age of fifty-nine years. His remains were deposited at Geneva. After the lapse of little more than twelve months they were removed thence to the Greenwood Cemetery, in answer to a request based upon the following resolution by the Cemetery Board, December second, eighteen hundred and fifty, as follows : " Resolved, that two lots for the use of the family of the late Major Douglass be designated by the Standing Committee, and when the remains of Major Douglass are deposited therein, the said Committee shall cause the lots to be suitably enclosed, and an appropriate monument to the memory of Major Douglass erected thereon." His remains now repose in that beautiful Necropolis, to the creation of which his admirable genius so largely contributed. No monument to his memory has yet been erected there. At this period the only permanent public memorial of his life and of his death, is to be found in the large and richly stained monumental windows of the South Aisle of Trinity Church, Geneva, upon which is traced the following inscription : " To the glory and praise of God. The children of the late David Bates Douglass, filled with affection for his memory, and with devout gratitude for his paternal precepts and Christian example, erect this Memorial Window."

Major Douglass in stature was several inches above the medium height, slender, but finely proportioned, with an

energetic, earnest movement and distinguished military presence. His features, without being regular or handsome, were strongly marked and striking; his hair was dark, and his eyes black, large, and restless; his voice deep-toned and firm. With brilliant conversational powers he combined a manner of address polished, quiet, and unostentatious. He was a favorite of the drawing-room and of the family circle. Religious in his proclivities, he superintended with pious vigilance the education of his family. His two eldest sons were graduates of Kenyon College. The eldest, Charles Edward, was destined for the Church. After graduating, he passed regularly through the University Course at Trinity College, Cambridge, England, with high honor, and is now the Rector of St. Stephen's Church, Brighton, England. The second son, Andrew Ellicott, entered into business in New York. The third son, Malcolm, graduated at Trinity College, Hartford, Connecticut, and is now the Rector of St. Paul's Church, Windsor, Vermont. From him many valuable papers were obtained and used in the preparation of this imperfect sketch of his distinguished and venerated father. The fourth son, Henry, after going partly through a college course, entered the U. S. Military Academy at West Point, and graduated in eighteen hundred and fifty-one. Major Douglass also left four daughters.

One might deem the years of Major Douglass comparatively few in number and his death premature, but in glancing at the leading events of his life from his early graduation at Yale College to the period of his death, with the reflection that within the narrow limits of a biography

of this nature, only the professional incidents could be recorded, he had lived long in useful mental exertion. Every hour had been occupied in earnest labor for the cultivation of others, or in plans for the military defence or public improvements of his country. While Professor of Architecture of the University of the City of New York, the University buildings were constructed from his design, being the first introduction into this country of the Elizabethan style.

The following tribute to the peculiar qualities of Major Douglass as a teacher, and his character as a Christian, is from the sermon of the Rev. Dr. Hale, President of Hobart College, upon the death of Major Douglass, and, coming from one who was so well qualified to judge, and who had been associated with him as a teacher and neighbor, gives it greater value and force :

“ By the caste of his mind and the qualities of his heart, no less than by the extent of his attainments, he was fitted to be a teacher. He had a rare facility in acquiring knowledge and making himself master of it in all its broadest principles and minutest details ; but it seemed to be his greatest pleasure and the peculiar tendency of his mind to impart it. He loved books, but if I may judge from my acquaintance with him, which was intimate, he was less a reader than a thinker. He looked reverently upon books—books which he desired and sought—and read them, not for amusement, but a serious occupation for the nourishment of his mind and heart. He read, therefore, not superficially, but intently, as he would have listened to the voice of a teacher in answer to earnest and important

inquiries. He possessed great powers of analysis, which he exercised, not in a captious or doubting spirit, but that he might better know and form the material whereon to exercise that faculty of his intellect, which was more peculiarly his characteristic, the constructive talent. Hence whatever he knew, he knew thoroughly and systematically. Hence his views, his opinions, his aims, were all definite. Hence the depth and clearness of his instruction. Hence in conversation he was still the teacher, and without any of the forms of argument, his discourse, clear in its own light, was full of information."

JONATHAN KNIGHT.

SURVEYOR AND CIVIL ENGINEER.

THE name of Jonathan Knight, associated as it is with the first important American railroad, of which he was the *first Chief Engineer* for a period of twelve years, must ever be regarded with interest by American Engineers.

Jonathan Knight, the son of Abel Knight and Ann S. Knight, was born in Bucks County, Pennsylvania, on the twenty-second day of November, seventeen hundred and eighty-seven. His father was a weaver by trade, but could survey land and teach school. He removed his family in eighteen hundred and one into the town of East Bethlehem, Washington County, where Jonathan resided until his death.

In early life the limited means of his father did not permit of his being educated in an academy or college; his facilities for instruction were necessarily confined to the ordinary primary schools then in the country. He was required by his father to be very industrious when quite young, and his unquenchable thirst for knowledge impelled him to read and study at home, mostly at night, thus acquiring a habit of close application to work and

study, and laying the foundation of a good American education.

He early showed a peculiar talent for the exact sciences and mathematics, and at the age of twelve years had worked Dilworth's Arithmetic through, and set the result down in a blank book. Soon after commencing with this Arithmetic, he was looking forward in the book, and discovered the process of extracting the square root, and so told his father, who hesitated to believe it; but he satisfied him by immediately working a number of examples. After this he needed but little instruction as he advanced in the science of numbers.

He studied surveying with his father, and when he was eighteen years of age he obtained Bonnycastle's Algebra, and studied it successfully into quadratic equations. At this time he had never seen a person who understood algebra. During the next year, being informed of a teacher who was teaching algebra in a neighboring town he went there, and received lessons in this branch for three or four months, which was the extent of his schooling in mathematics. About this time he cultivated the habit of solving questions or problems mentally, when engaged in working on his father's farm, or in drawing fire-wood home in the winter. Upon starting to the woods for a load he would read a question, and when he returned and unloaded his sleigh, he would go into the house to warm, and while there set the solution down, and read another question, then start to the woods again, and so continue. He was in the habit, at an early age, upon entering a building that was being erected, of obtaining its dimensions, and

then proceed to estimate the quantity of materials used in the construction ; if brick, the number of them, and even the number of nails and shingles used.

In eighteen hundred and nine he married Ann Heston, in a meeting of the Society of Friends, in accordance with their Order, and continued during his life in the fellowship of that Society. .

When twenty-one years of age, Jonathan commenced teaching school and surveying land on his own account, which occupation he pursued until the spring of eighteen hundred and fifteen, when he purchased some land, intending to devote his time to farming and surveying. His engagements for surveying land became so numerous that he found very little time to attend to his farm. And the next year (eighteen hundred and sixteen) he was appointed by the State Government of Pennsylvania to make the surveys and a map of Washington County, in order to facilitate the forming of Melish's map of the State. This duty involved much field labor, the instrumental surveying requiring one hundred days' work in its performance. This service having been satisfactorily performed, Mr. Knight served three years as County Commissioner, to which office he was elected by the people.

Soon after, he entered upon civil engineering, having served in subordinate stations in the preliminary surveys of the Chesapeake and Ohio Canal, and in those for the National Road between Cumberland and Wheeling. He was appointed, in eighteen hundred and twenty-five, by the Federal Government, a Commissioner to extend that road from Wheeling, through the States of Ohio and Indiana, to Illinois.

In eighteen hundred and twenty-two he was elected a member of the Legislature of Pennsylvania, and served in the House of Representatives, and in the Senate for six consecutive sessions.

Immediately after the organization of the Baltimore and Ohio Railroad Company, in April, eighteen hundred and twenty-seven, Jonathan Knight and Colonel Stephen H. Long were selected by the Board of Directors to make the necessary surveys of the country through which the road was to pass. The Government of the United States, justly appreciating the importance of the enterprise, also extended to it a most liberal patronage. Several able and efficient members of the Topographical Corps were detailed to the service of the Company, among whom were Captain William Gibbs McNeill, Lieutenants Joshua Barney, Isaac Trimble, Richard E. Hazard, William Cook, Walter Gwynn, and John L. Dillahunty, of the United States Army, and William Harrison, Jr., Assistant Engineer, who proceeded to examine the various routes from the city of Baltimore to the valley of the Potomac, and along that river and valley to Cumberland, and from thence to a general reconnaissance of the country between the Potomac and the Ohio river. Messrs. Knight and Long, on the fifth of April, eighteen hundred and twenty-eight, made an able report, accompanied by statements of the officers detailed by the Government, recommending what they deemed to be the most practicable route.

These reports having been carefully examined by the Board of Directors, President Philip E. Thomas reported to the stockholders that the preliminary examinations had

resulted in a conviction of the entire practicability of a railroad from Baltimore to the Ohio river, and that "they were convinced that of the various routes which had been suggested, the one along the valley of the Patapsco, and thence in the direction of Linganore Creek, to the Point of Rocks, was so decidedly preferable as to preclude any hesitation in awarding it the preference."

The construction of the road was commenced on the fourth of July, eighteen hundred and twenty-eight, and the event was celebrated with great ceremony. The first stone was laid by the venerable Charles Carroll, of Carrollton, then over ninety years of age, on the south-west line of the city. In the month of August following, the location of the line, adopted by the Directors, having been effected and unanimously approved by the Board of Engineers, contracts were entered into for the grading and masonry of fourteen miles, between the city and Ellicott's Mills, on the Patapsco. On this section of the road is the "Carrollton Viaduct," a fine structure of dressed granite, with an arch of eighty feet span, over Gwynn's Falls, near the city.



CARROLLTON VIADUCT.

A few miles further on a deep cut was required—famous for the difficulties it presented in the early history of this road—seventy-six feet in extreme depth and nearly half a mile in length. The traces of the slides and gullies of over forty years are to be seen upon its furrowed sides, tinted with various ochrous colors of the richest hue. Eight miles from Baltimore, the open country of sand and clay ends, and the region of rock begins at the entrance to the gorge of the Patapsco river. At this point is the “Thomas Viaduct,” a noble granite structure of eight elliptical arches, each of about sixty feet chord, spanning the stream at a height of sixty-six feet above its bed, and of a total length of seven hundred feet. This bridge is on the Washington branch road, which departs from the main line at this place. Three miles from the Relay House, on the main road, is the “Patterson Viaduct,” a fine granite work of two arches of fifty-five feet, and two of twenty feet span over the river, at a very rugged part of the ravine.

At Ellicott’s Mills, the Frederick Turnpike is crossed by the railroad upon the “Oliver Viaduct,” a handsome stone bridge of three arches of twenty feet span. The road was completed to this point and opened for travel on the twenty-fourth of May, eighteen hundred and thirty. Those who had doubted the utility of the enterprise became its advocates and supporters, the whole country was satisfied, and railroads were commenced in other States on the result of this experiment. The following interesting account of the early history of this pioneer improvement, and the motive power used upon it, is

copied from an interesting lecture of the Hon. John H. B. Latrobe, the distinguished legal counsellor of the Company, delivered in Baltimore, in eighteen hundred and sixty-eight :

“ It is amusing, with the knowledge we now have of such things, to look back to the fancies of eighteen hundred and twenty-five and six. In the latter year a sufficient feeling had been gotten up to justify a town meeting on the subject of Western communications. A committee was appointed, resolutions were adopted, a charter, modelled mainly on the old turnpike charters, was prepared, the Legislature was applied to successfully, and, in *March, eighteen hundred and twenty-seven, the first railroad company in the United States for general purposes of transportation* was launched into existence, with a capital of one and a half million dollars, with liberty to increase it, and the city of Baltimore and the State of Maryland were authorized to subscribe to the stock.

Then came a scene which almost beggars description. By this time public excitement had gone far beyond fever heat, and reached the boiling point. Everybody wanted stock. The number of subscribers were to be apportioned if the limit of the capital should be exceeded, and every one set about obtaining proxies. Parents subscribed in the names of their children, and paid the dollar on each share that the rules prescribed. Before a survey had been made —before common sense had been consulted even, the possession of stock in any quantity was regarded as a provision for old age, and great was the scrabble to obtain it. The excitement in Baltimore roused public attention else-

where, and a railroad mania began to pervade the land. But Baltimore led all the rest ; there can be no doubts of that.

“ Then came the surveys. The greatest work in the country in those days was the National Road from Washington city to Wheeling, and its Chief Engineer, Jonathan Knight, a member of the Society of Friends, a profound mathematician, and an honest and able man, was brought into the service of the new Company. Along with him came his Superintendent of Construction, Mr. Weaver, who had built miles and miles of turnpike in Ohio. They came from a sandstone country, where rocks could be cut like cheese almost, to win a pretty costly experience in the granite districts of Maryland. To these were added engineers from the United States Army, who brought West Point to bear upon the road. A mission of engineers were sent to England while the surveys were going on at home. Every thing was done with an eager enthusiasm that was unexampled even in our enterprising annals.

“ In the beginning, no one dreamed of steam upon the road. Horses were to do the work ; and even after the line was completed to Frederick, relays of horses trotted the cars from place to place. In this, the Relay House, at the junction of the Washington branch, obtained its name. One great desideratum was to reduce the friction of the axles in their boxes, and about this time Mr. Ross Winans made his appearance in Baltimore, and instantly became a celebrity, with his friction wheel, unquestionably an ingenious and beautiful contrivance.

"The town went wild with 'the Winans friction wheel,' and the speaker remembers well, as though it were but yesterday, seeing Charles Carroll, of Carrollton, who was the great man on all great occasions in Baltimore, seated on a little car in one of the upper rooms of the Exchange, and being drawn by a ridiculously small weight attached to a string passed over a pulley and dropping into the hall below. Around him were all the prominent men in Baltimore, and all were as much pleased as children with a new toy. In fact, there was a verdant freshness about railroad things in those days that it is wonderful to recollect.

And yet the Company, stumbling along, with many a fall and many a bruise, made headway notwithstanding, and gave to the Companies fast multiplying in all directions the benefit of its experience. Nothing was more sought after by engineers than the Company's reports. With a great deal now useless there was mixed a great deal of scientific and mathematical information. Accurate tables for the location of curves, for estimating quantities, for regulating grades, were to be found there. The Company's very errors imparted lessons of wisdom. What now seems simple was then abstruse, and it was only natural that the managers of new works should resort to the first railroad which had arrived at practical results in the United States, for information.

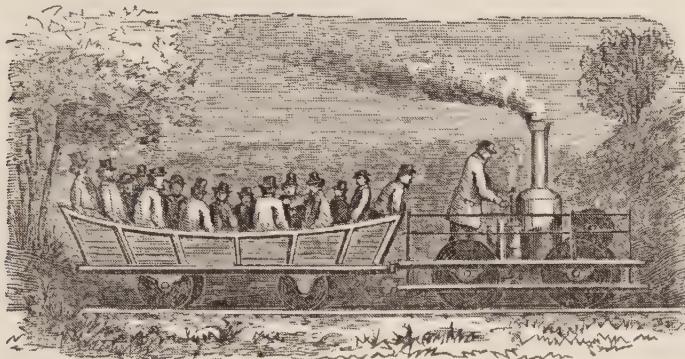
"When steam made its appearance on the Liverpool and Manchester Railroad it attracted great attention here. But there was this difficulty about introducing an English engine on an American road. An English road was

virtually a straight road. An American road had curves sometimes of as small radius as two hundred feet. There was not capital enough in the United States applicable to railroad purposes, to justify engineers in setting nature at defiance. If a tunnel through a spur could be saved by a road around it, the tunnel was postponed and the circuitous route adopted, although the distance was increased in consequence ; so, if embankments could be saved by heading valleys, in place of crossing them. This led to sharp curves here, where they would have been straight lines in England. No better illustration of this is to be seen than near the Relay House, or Washington Junction of the Baltimore and Ohio Railroad, where the curve, as the road turned into the gorge of the Patapsco, was originally located with less than three hundred feet radius, to avoid the necessity of the cut, that has since been made through the rocky, northern jaw of the gorge. A tunnel is now cut at the Point of Rocks, through the hard intractable material which is there met with, in a spur of the Catoctin mountain, which, in the first instance, the road was located to avoid. For a brief season it was believed that this feature of the early American roads would prevent the use of locomotive engines. The contrary was demonstrated by a gentleman still living in an active and ripe old age, honored and beloved, distinguished for his private worth and for his public benefactions ; one of those to whom wealth seems to have been granted by Providence that men might know how wealth could be used to benefit one's fellow-creatures. The speaker refers to Mr. Peter Cooper, of New York. Mr. Cooper was

satisfied that steam might be adapted to the curved roads which he saw would be built in the United States, and he came to Baltimore, which then possessed the only one on which he could experiment, to vindicate his belief. He had another idea, which was that the crank could be dispensed with in the change from a reciprocating to a rotary motion ; and he built an engine to demonstrate both articles of his faith. The machine was not larger than the hand-cars used by workmen to transfer themselves from place to place ; and, as the speaker now recalls its appearance, the only wonder is that so apparently insignificant a contrivance should ever have been regarded as competent to the smallest results. But Mr. Cooper was wiser than many of the wisest around him. His engine could not have weighed a ton ; but he saw in it a principle which the forty-ton engines of to-day have but served to develop and demonstrate.

"The boiler of Mr. Cooper's engine was not as large as the kitchen boiler attached to many a range in modern mansions. It was of about the same diameter, but not much more than half as high. It stood upright in the car, and was filled above the furnace, which occupied the lower section with vertical tubes. The cylinder was but three and one half inches in diameter, and speed was gotten up by gearing. No natural draught could have been sufficient to keep up steam in so small a boiler ; and Mr. Cooper used therefore a blowing apparatus, driven by a drum attached to one of the car wheels, over which passed a chord that in its turn worked a pulley on the shaft of the blower.

"And this was the first locomotive for railroad purposes ever built in America, and this was the first transportation of persons by steam that had ever taken place on this side of the Atlantic.



FIRST AMERICAN LOCOMOTIVE.

"Mr. Cooper's success was such as to induce him to try a trip to Ellicott's Mills, and an *open car*, the *first used upon the road* already mentioned, having been attached to his engine and filled with the Directors and some friends, the speaker among the rest, the *first journey by steam in America* was commenced. The trip was most interesting. The curves were passed without difficulty at a speed of *fifteen miles an hour*; the grades were ascended with comparative ease; the day was fine, the company in the highest spirits, and some excited gentlemen of the party pulled out memorandum-books, and when at the highest speed, which was *eighteen miles an hour*, wrote their names and some connected sentences, to prove that even at that great velocity it was possible to do so. The return trip from the Mills, a distance of thirteen miles, was made in

fifty-seven minutes. This was in the summer of eighteen hundred and thirty."

LETTER FROM MR. LATROBE.

BALTIMORE, January 29th, 1870.

Genl. CHARLES B. STUART:

DEAR SIR,— * * * *

I give above all that I recollect of the *tout ensemble* of the first trips to Ellicott's Mills, described in my lecture, to which you refer.

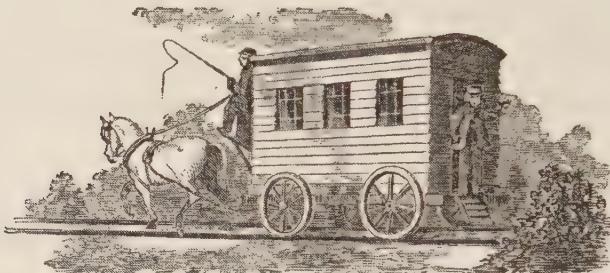
It is generally correct in the *look* of the Cooper Engine, save that perhaps the boiler is larger than it should be in proportion to the size of Mr. Cooper, the Engineman for the occasion. The fan is shown, that was driven by a cord retained in a groove in a wooden rim attached to the wheel. I think the cylinder was upright and fastened to the boiler, and that the piston rod moved a cross-head, which had connecting rods that either worked cranks or a spur wheel meshing into a pinion on the axle, or was connected with Mr. Cooper's contrivance to dispense with the crank as a means of converting the reciprocating motion of the piston into a rotary motion. There was a narrow platform outside the wheels and below the axles, which I well recollect, and a railing that one might hold on to, while standing on the platform. I recollect it, for when steam was let into the cylinder for the first time in the car shops at Mount Clare, I remember that several of the Directors and myself stepped upon the platform and steadied ourselves by the rail when the wheels made their first revolution, and the first yard of movement followed.

The passenger car is about right in the above representation of it. The likeness of the passengers is not flattered ; the idea of *a perfect jam*, however, is sufficiently indicated. These I do not recollect in detail. About the *tout ensemble*, the general effect, there can be no question, nor can there be any question with regard to the facts stated by me, as such, in the lecture you refer to. * * * *

I have brought to my mind by this sketch, the whole scene of the railroad trip, and am altogether satisfied with my illustration, not as a work of art, of course, but as the *idea* of that which startled the country people along the line of the Patapsco, who turned out to gaze upon the strange exhibition on the twenty-eighth of August, eighteen hundred and thirty.

It may be interesting here to compare the pioneer American passenger car attached to the Cooper Locomotive, with the first passenger car built for the Stockton and Darlington, the first railroad for passengers constructed in England, in eighteen hundred and twenty-five, from a design by Mr. Stephenson, C. E. It was, however, a very unpretentious, and indeed a somewhat uncouth machine, more resembling the caravans still to be seen at country fairs, containing the "Giant and the Dwarf," and other wonders of the world, than a passenger coach of any extant form. A row of seats ran along each side of the interior, and a long deal table was fixed in the centre, the access being by means of a door in the rear end, in the manner of an Omnibus. Mr. Stephenson was consulted as to the name of the coach, and he at once suggested, "*The Experiment*," and by this name it was

called. The Company's arms were afterwards painted on its side with the motto, "*Periculum privatum utilitas publica.*"*



FIRST RAILROAD PASSENGER CAR.

Between Baltimore and Ellicott's Mills there were several curves in the line, of four hundred feet radii, and the use of locomotives on this portion of road was thought to be impracticable. The manner, however, in which this obstacle was overcome is alluded to by Mr. Ross Winans, who witnessed the performance of the engine constructed and run by Mr. Cooper, in a letter to Philip E. Thomas, President of the Railroad Company. This admirable effect of turning curves of four hundred feet radii at fast speed with very little if any resistance, I believe to be new in the history of railways, or at least that it is brought to a greater degree of perfection on the Baltimore and Ohio Railroad than on any other. It results from the judicious and scientific construction of the tread of the main wheels introduced by Mr. Knight, your Principal Engineer, by combining the cone and cylinder,† which

* Smilie's "Lives of Engineers," third volume, page 170.

† To avoid the friction of the flanges of the wheels against the rails, Mr. James Wright, of Columbia, Pa., had invented a method which consisted in giving a

expedient, as far as I know, has never been attempted in Europe.

The trite adage that "necessity is the mother of invention," was never more fully verified than in the adaptation of rolling machinery to this railway. "The unavoidable curves and ascents of the road induced many to believe that the use of steam to any extent was impracticable, and that horse-power must be applied, at all events upon much the greater portion of the road."* To overcome these impediments, Mr. Knight instituted a series of most careful experiments, based on elaborate scientific calculations in reference to the best form of rail; the best form for the tread of the wheel; resistance to motion; the tractive power of horses and locomotives; adhesion of wheels upon the rail, and other relative subjects bearing upon the most efficient adaptation of machinery to the movement of railway trains. His conclusions, deduced from these experiments, are recognized as correct, and are accepted by railway engineers to the present time.

During the construction of the railroad between Baltimore and Ellicott's Mills, Mr. Knight visited England to acquire knowledge in that then new department of Civil Engineering. Upon his return, in eighteen hundred and thirty, he was appointed Chief Engineer of the Company, but his duties did not embrace the superintendence of construction. He located the road, planned the structures

conical form to the rim of the wheel, so that wherever the road curves, the larger part of the rim of the outer wheel comes on the rail, and consequently travels faster than the inner wheel.—*Treatise on Railroads by Thomas Earle, Phila.*, 1830.

* Report, President and Directors B. and O. Railroad, Oct., 1832.

and machinery, and prepared the work for contract, after which it was placed in charge of the Engineer of Construction. This organization continued until eighteen hundred and thirty-six, at which time the main stem of the road was completed to Harper's Ferry, and the branch to Washington in operation. The road was opened to Harper's Ferry, eighty-two miles from Baltimore, December first, eighteen hundred and thirty-four, at a cost of about four millions of dollars.

In eighteen hundred and thirty-five Mr. Knight made a personal examination of the country between Cumberland and the Ohio river, to ascertain its general adaptation to a route for the railroad across the Alleghany range. His report of this reconnoissance is comprehensive and instructive, and ably develops the principle upon which a railroad, located over such a country, should be made. In these examinations he exhibited the correctness of eye, and the accuracy in computing distances and elevations, for which he was very remarkable.

In eighteen hundred and thirty-nine the construction of the Baltimore and Ohio Railroad, between Harper's Ferry and Cumberland, ninety-eight miles, was commenced, and opened for travel in November, eighteen hundred and forty-two. During the progress of this work, and until April of the latter year, Mr. Knight was employed in various duties of a general character, occasionally visiting the line to inspect the work, but chiefly employed in the preparation of reports upon various subjects connected with the general interests of the Company. The able reports and elaborate analytical papers which he

prepared during a series of years, and which appear in the annual publications of the Company, do him great credit as a scientific investigator. In April, eighteen hundred and forty-two, he resigned his position as an officer of the Company, and retired to his farm in Pennsylvania. Subsequently, however, he was employed as Consulting Engineer by the Company on important engineering questions, and, in eighteen hundred and forty-four and forty-seven, he co-operated with the city of Wheeling in the controversy and negotiations between that city and the Baltimore and Ohio Railroad Company, respecting the route to Wheeling, and which was compromised in eighteen hundred and forty-seven; the Company accepting, in part, the line recommended by him, and commencing the work in eighteen hundred and fifty.

"Mr. Knight," says Benjamin H. Latrobe, the successor of the subject of this sketch, in a recent letter to the author, "showed much science and skill in his locations. His thorough knowledge of elementary mathematics, and his readiness in applying them to the solution of the many questions which arose in that early day of railroad practice, and his investigation of the elements of resistance to cars moving upon railroads, displayed fine powers of analysis, and were also marked by sound judgment in the statement of results. Some of these investigations were published in the early annual, and other reports of the Company. These papers display his distinguished ability as an investigator of railroad questions, and great force and perspicuity as a writer, the latter especially creditable to one whose early education had of necessity been so limited.

In his location of the Washington Branch Road, Mr. Knight exhibited much judgment. Although this road was chiefly built for passenger business, and the features of the country were unfavorable for low grades, he made twenty feet per mile the limit, and the cheap working of the line, with its heavy travel and increasing trade, is now justifying his foresight. In locating the part of the main stem beyond Ellicott's Mills, he adhered to the same principles as far as was practicable, upon a route of so different a character. He personally superintended the location over Parr's Ridge for inclined planes, and thence onward to the Point of Rocks, on the Potomac, sixty-seven miles from Baltimore. Here commenced the great contest with the Chesapeake and Ohio Canal Company for the right of way up the Potomac, which Mr. Knight conducted on the part of the railroad company, with signal talent, both in adjusting the location of the two works on the disputed ground, and in the controversial papers, wherein the relative merits of canals and railroads were discussed in that connection."

The leading characteristics of Mr. Knight, as a professional man, were strongly marked, and entitled him to a high rank in the roll of American Civil Engineers. His natural aptitude for the acquisition of knowledge in the exact sciences, and especially those which depend upon the skilful use of algebraic analysis, was unsurpassed. The habit of close thinking, into which he was led by the natural tendencies of his mind to mathematical investigation, made him reason rigidly on all subjects, and gave a philosophical cast to his conver-

sation, upon almost every topic that he touched. Yet his remarks were not a series of dry abstractions, but were practical in their bearings, and enriched by illustration and anecdote. In political economy he was well versed, and expressed enlightened and comprehensive views upon the subject of banking, trade, manufactures and agriculture, of the last of which he possessed much practical knowledge, derived from experience and careful observation. Politics, also, was a favorite theme with him, and upon public measures he always expressed broad and national views. He discussed the characters of our public men with great spirit, and often with a sarcastic humor which marked his conversations upon most subjects. The character of Henry Clay appeared to be his ideal of a statesman and orator.

In private life, he was distinguished by many excellent qualities. He reared a large family—ten children—fulfilling his domestic duties in the most exemplary manner, bringing up his children in the fear of God, providing for them with a judicious regard to their several capacities and dispositions. He left a comfortable estate, after having settled all his children during his own lifetime; and among his neighbors and many friends, a character of unsullied probity and consistent Christian kindness.

Mr. Knight was taken suddenly ill with bilious colic, in a very severe form, at his home, on the thirteenth day of November, eighteen hundred and fifty-eight. In a few hours inflammation had set in, causing a severe pain and a continued oppressive sensation in the chest. He died on the ninth day of his illness, *being the seventy-first*

anniversary of his birth-day. During his last illness he was very patient and calm, conversed little, but always spoke pleasantly to those about him, recognizing them until the last moment, and with his last words expressed his belief "that he had made his peace with God and had no matter to make up with any man ; and that he believed he was entering upon a state of rest and happiness in the life to come."





Yours truly
Wm. H. Linton Jr.

BENJAMIN H. LATROBE,

CIVIL ENGINEER

BENJAMIN H. LATROBE was born on the nineteenth of December, eighteen hundred and six, in the city of Philadelphia. He was the fifth child and youngest son of Benjamin H. Latrobe, well known as an eminent civil engineer and architect, in the early part of the present century, and especially in connection with the Capitol of the United States, the best features of which were designed and executed by him, although he did not live to complete the building. Mr. Latrobe, Senior, was descended from a French Protestant family, which had emigrated to Ireland. His father was an English clergyman, but his mother was a Pennsylvania lady of the Antes family, well known in Montgomery county of that State. He emigrated to America in seventeen hundred and ninety-eight ; and being a widower, married in eighteen hundred, the eldest daughter of Isaac Hazlehurst, a Philadelphia merchant, and also an Englishman by birth.

The subject of the present memoir was not educated for the profession he afterwards pursued, and to which he might have been so well trained in his father's office. He was intended for the law ; and, although his father died

when his son was but fourteen, his purpose in regard to him was adhered to, and having graduated at the Roman Catholic College of St. Mary's, in Baltimore, at the age of seventeen, he entered a law office, as a student, and was admitted to the Baltimore bar before he had completed his twentieth year. He went soon after to New Jersey, and commenced the practice of law in Salem County ; but the climate not agreeing with his health, he returned to Baltimore in eighteen hundred and twenty-nine. Having meanwhile discovered that the legal profession was not to his taste, he left it the following year and entered the service of the Baltimore and Ohio Railroad Company, as an assistant of Jonathan Knight, then Chief Engineer of that Company.

The brother of the subject of our sketch, J. H. B. Latrobe, Esq., the distinguished legal counsellor of the Baltimore and Ohio Railroad Company, was educated as an engineer ; but maturity brought to him a taste for metaphysics and law, and they have each chosen the path for which nature intended them, and are leading men in their respective professions.

Benjamin H. Latrobe, being already an accomplished draughtsman, and a fine mathematician, soon rose through several subordinate positions, to the rank of principal assistant to Mr. Knight, and, in eighteen hundred and thirty-two, began the location of the Washington Branch Railroad, under his directions. This service occupied him until the close of eighteen hundred and thirty-three. In the following year, he located that portion of the Baltimore and Ohio Railroad, between the Point of

Rocks and Harper's Ferry, which had not been previously established by Mr. Knight, conjointly with the Engineer of the Chesapeake and Ohio Canal Company.

In the same year he reconnoitred and reported upon a railroad route from Harper's Ferry to Chambersburgh, through Hagerstown, Maryland.

In eighteen hundred and thirty-five, Mr. Latrobe was appointed Chief Engineer of the Baltimore and Port Deposit Railroad, which was located and built under his direction from Baltimore to Havre-de-Grace, thirty-four miles. The features which distinguished this road were, three bridges of considerable length, two of them with draws, over rivers of moderate depth of water, but almost unfathomable mud. They were supported upon piles, and were the first long railroad bridges of this description erected in the United States. The ferry at Havre-de-Grace was also peculiar, the cars, with freight and baggage, being transported across the river, three-fourths of a mile wide, upon tracks laid upon the upper deck of a steamboat, so as to avoid breaking bulk ; a plan since adopted successfully upon other railroads in this country. Mr. Latrobe left the service of the Baltimore and Ohio Railroad, when he entered the other, in eighteen hundred and thirty-five, but was recalled in eighteen hundred and thirty-six, and appointed "Engineer of Location and Construction," by that Company.

In this capacity, he executed all the surveys, planned and superintended all the works of construction, with the advice of Jonathan Knight, the Chief Engineer. He remained in the service of the Baltimore and Port Deposit

Railroad Company until the opening of that work in July, eighteen hundred and thirty-seven, and thenceforward devoted his exclusive attention to the Baltimore and Ohio Railroad surveys, which were prosecuted during that year to Wheeling and Pittsburg, on the Ohio. In eighteen hundred and thirty-eight Mr. Latrobe made an elaborate report upon these surveys, which extended over a section of a mountainous country upwards of three hundred miles in length and fifty or sixty miles in breadth, in a manner to give much professional credit to himself. It was through this able report that Mr. Latrobe became well known to the profession throughout the country, and he gained soon after a higher reputation by a report upon the principal railroads of the Eastern and Middle States, in which he was associated with Mr. Knight.

In this year, also, the four inclined planes over Parr's Ridge were replaced by a railroad, with grades of eighty feet per mile, as located by Mr. Latrobe and constructed under his supervision, and the general direction of the Chief Engineer. Some important changes were also made in the bed of the road, by which a part of its most objectionable curves were dispensed with.

In eighteen hundred and thirty-nine the Baltimore and Ohio Railroad from Harper's Ferry to Cumberland, ninety-eight miles, was finally located, and its construction, upon the plans prepared by Mr. Latrobe and approved by Mr. Knight, commenced. The work of chief interest upon that part of the road were three tunnels—the longest twelve hundred feet—and several bridges of

considerable magnitude, built of timber, upon a plan approved by Mr. Latrobe, and in which arch braces were adopted, with counterbraces and tie-rods between them. The plan of these structures is fully described in Haupt's work on Bridges.

This important division of the road was opened for travel in November, eighteen hundred and forty-two, Mr. Latrobe having previously been appointed Chief Engineer, upon the retirement of Jonathan Knight in April of that year.

After the completion of the road to Cumberland, Mr. Latrobe was occupied during the succeeding years, up to eighteen hundred and forty-seven, in a variety of duties, all of which, however, related to the extension of the railroad beyond Cumberland to the Ohio river. He reconnoitred the country through Virginia, in eighteen hundred and forty-three and forty-four, and in the latter year pursued his examinations into Ohio, to the leading centres of trade of that State. He also visited Richmond during each winter of these years, in aid of the efforts the Company were making to obtain an acceptable right of way through Virginia, and was deputed by President McLean, then on the eve of his departure as Minister to England, to make the annual report to the stockholders, in July, eighteen hundred and forty-five, and on his recommendation they rejected the Virginia law of that year.

The transportation department of the railroad from Baltimore to Cumberland, was also under his general direction during that time, and in eighteen hundred and

forty-six the old plate rail track was replaced by T rail, and many additional changes were made in the road bed, and its most objectionable curves.

In eighteen hundred and forty-seven the surveys west of Cumberland were resumed, and in that, and the two succeeding years, the line to Wheeling, two hundred miles in length, was located, and most of it placed under contract. In the location, plans, and construction of this part of the Baltimore and Ohio Railroad, Mr. Latrobe performed a most difficult task. The country presented unusually bold features, even for a mountainous region. Two main summits, one of twenty-six hundred, and one of two thousand feet above tide water, had to be passed, with a valley between them less than fourteen hundred feet above the ocean. Lines of better grade might have been had, but with shorter curves and a greater expenditure of distance and cost of construction. Mr. Latrobe selected the most direct, and easiest to build, although it involved an inclination unprecedented in leading railroad routes.

The principal summit of twenty-six hundred feet above tide water, between the Potomac and Youghiogheny, was passed by a grade averaging one hundred and sixteen feet to the mile, for fifteen continuous miles. The same grade was used for eight and one-half miles in descending to the valley of Cheat river; and in crossing the second summit of two thousand feet, between this river and Tygart's Valley, about six miles of one hundred and five feet grade was used on either side.

Mr. Latrobe had adopted this location on his own responsibility, as the Company's Chief Engineer; but as

it presented novel and important questions, a Consulting Board, composed of Jonathan Knight, Capt. John Childe, and himself, was appointed to consider the subject. Under the direction of this Board, new surveys were made in eighteen hundred and forty-eight, which resulted, however, in showing that the best ground had already been selected ; and in an elaborate report, made soon after, the location of Mr. Latrobe was approved by his colleagues, and finally adopted by the Company.

The road was accordingly constructed upon that line, and its natural features, and the works connected with them, have become well known throughout the country. Upon the two hundred miles between Cumberland and Wheeling, there are twelve tunnels of various lengths,—the longest the “Kingwood,”—four thousand one hundred feet, through a compact slate rock, overlaid in part by a good limestone roof, and for the rest of its length supported by brick arching. There is a long deep cut at each end of the tunnel. It was worked from both ends, and from three shafts fifteen by twenty feet square, and one hundred and eighty feet deep. The greatest height of the ridge over the tunnel is two hundred and twenty feet. The time employed on the work was about two years and eight months, and the number of cubic yards removed in the tunnel, was about ninety thousand, together with about one hundred and ten thousand yards of earth and rock outside, for the approaches.*

* At the crossing of the mountain over this tunnel, previous to its completion in eighteen hundred and fifty-three, the grade was upwards of *five hundred feet per mile*, over which a locomotive engine propelled a single car at a time, weigh-

The next most important work was the "Doe Gully" tunnel, twelve hundred feet in length, where a bend in the Potomac river is crossed, and a distance of nearly four miles saved. The approaches to this work are imposing; for several miles on each side of the tunnel, the road occupies a high level on the steep hill sides, affording an extensive view of grand mountain scenery. The tunnel is through a compact slate rock, which is arched with brick to preserve it from future disintegration by atmospheric action. The fronts or façades of the arch, are of fine white sandstone, procured from the summit of the neighboring mountain. The height of the hill above the tunnel, is one hundred and ten feet. The excavations and embankments adjacent, are very heavy, through slate rock. The bridges are also numerous, and the "trestling," across the gorges, on the ascent of the Cheat River Hill, are structures of novel character, being viaducts supported by slender pillars of cast iron, very light in appearance, yet strong, and durable. One of these viaducts is forty-six, and the other fifty-eight feet high ; the former resting on a solid wall of masonry, whose foundation is one hundred and twenty feet below the base of the columns; the latter on a similar wall, with foundations seventy-four feet below base of columns. The pillars lean inwards to give stability, and are thoroughly tied and braced, and carry two tracks of rails at the grade of the road.

ing, with its load, *thirteen tons*, at a speed of upwards of ten miles per hour. When the track was wet or frosty, the engine and its load occasionally slipped backwards, and often ran with locked wheels, down to the bottom of the grade without injury.

In the design and erection of the bridges and viaducts, Mr. Latrobe was assisted by Albert Fink, a talented German engineer, who was associated with Mr. Latrobe as an assistant for several years, and is now earning a high reputation as an engineer and bridge architect, in the South-West.

The cost of the Baltimore and Ohio Railroad from Baltimore to Wheeling, three hundred and seventy-nine miles, completed June first, eighteen hundred and fifty-three, was fifteen millions six hundred and twenty-nine thousand dollars, including nearly one million dollars for reconstruction east of Cumberland, after the road was opened to that point in November, eighteen hundred and forty-two.

The working of the Baltimore and Ohio Railroad, between Cumberland and Wheeling, has abundantly manifested the judiciousness of its location and manner of construction. The high grades have been operated with great economy and entire safety, by means of a class of locomotives, using the extremely cheap mineral fuel which abounds in that region. In addition to the work already described, and upon which Mr. Latrobe has been engaged as Chief Engineer, he acted, from eighteen hundred and fifty to fifty-four, as Consulting Engineer of the Cincinnati, Hillsboro and Parkersburg Railroad, and, in eighteen hundred and fifty-five, the Fredericksburgh and Gordonsville Railroad Company employed him in the same capacity.

In eighteen hundred and fifty-four he visited South Carolina to examine the location of the Blue Ridge

Railroad of that State, upon which he made an able report of some length, which was published by that Company. He again visited the road in eighteen hundred and fifty-seven to give his professional testimony upon questions connected with the object of his previous visit.

In eighteen hundred and fifty-one Mr. Latrobe was appointed Chief Engineer of the North-Western and Virginia Railroad Company, extending from Grafton, a point on the Baltimore and Ohio Railroad, to Parkersburg on the Ohio river, ninety-two miles below Wheeling. In the contest for the right of way through Virginia for the Baltimore and Ohio Railroad, Mr. Latrobe always favored the most direct line to Cincinnati, and opposed the Wheeling terminus. He, therefore, entered *con amore* into the construction of the Parkersburg Railroad, under the charter which the citizens of that place had succeeded in obtaining.

The country between Grafton and Parkersburg was very much broken, and required patient examination to secure the best line, which was only obtained by a free resort to tunnelling through the numerous high and sharp ridges dividing the many watercourses. No less than *twenty-three tunnels*, in one hundred and four miles, had to be driven, the longest twenty-seven hundred feet. These tunnels are the most striking features of the road. There are many bridges, but none of great magnitude, and several embankments, but none of extraordinary altitude or length. The depot arrangements upon the Ohio river at Parkersburg are worthy of attention, for their excellent facilities for handling freight by means of machinery used for raising and lowering it from steamboats.

In eighteen hundred and fifty-six, Mr. Latrobe was appointed President of the Pittsburgh and Connellsville Railroad Company, and also of the Northern Virginia Railroad Company. From this last position he retired in the latter part of eighteen hundred and fifty-seven, and devoted his whole attention to the direction of the Pittsburgh and Connellsville Railroad, performing, from early in eighteen hundred and fifty-eight, the duties of Chief Engineer of the same Company. In eighteen hundred and sixty-four he retired from the Presidency of this Company, retaining, however, the Chief Engineership, which he still holds.

In eighteen hundred and sixty-three, he became Consulting Engineer of the Philadelphia, Wilmington, and Baltimore Railroad Company, in connection with the bridge then about to be built across the Susquehanna river at Havre-de-Grace. In eighteen hundred and sixty-five, he was appointed Consulting Engineer of the Missouri Railroad Company, more especially in reference to the bridge about being erected over the Missouri river at St. Charles, which position he held for about two years.

In eighteen hundred and sixty-six he was appointed Consulting Engineer to the Governor and Council of Massachusetts, in connection with the Troy and Greenfield Railroad, and Hoosac Tunnel, and held the office until January, eighteen hundred and sixty-nine, when he resigned.

Early in eighteen hundred and sixty-nine, on the invitation of the late John A. Roebling, he became one of a

Consulting Board of Engineers upon the plans of the "East River Suspension Bridge," and continued to act with the Board until its services were terminated, and report made in the autumn of the same year.

Such is a brief summary of forty years of the professional life of this distinguished Civil Engineer. In looking through the numerous reports from his able pen, the author is at a loss to select from among them, such as might be considered most worthy of notice and deserving of preservation, as part of the professional history of his time.

In eighteen hundred and forty-six, when the Baltimore and Ohio Railroad Company was hesitating whether it would extend its road west of Cumberland to Pittsburgh through Pennsylvania, or to some point below on the Ohio, in Virginia, the Pittsburgh and Connellsville Railroad Company, having located a part of its road, offered its charter to the Baltimore and Ohio Railroad Company (to whom Pennsylvania had refused to renew its former right of way on terms that would be accepted).

The Company decided, however, to go through Virginia rather than through Pennsylvania, even if they were compelled to make their terminus on the Ohio as far down as Wheeling. This decision was an unfortunate one for the Company ; for if the road had been first made to Pittsburgh, the State of Virginia would have finally accorded the right to Parkersburg (as has since been proved), and the one hundred miles to Wheeling would have been saved, and could well have been spared, for in the final arrangement it has become mainly a local road.

Mr. Latrobe is now engaged in endeavoring to accomplish that which he desired to have seen effected at first, and should he be so favored, may live to fill up the measure of his professional ambition—the completion, under his direction, of two great lines of railroad which are equally necessary to Baltimore.

He has been invited to take charge of other lines of railroads, but the interest he has always felt in the city of Baltimore, and the completion of her connections with the West, has always led him to decline engagements incompatible with that paramount object of his career as a Civil Engineer.

Mr. Latrobe is as distinguished for his modesty, urbanity and gentlemanly deportment, as for his eminence as an Engineer. When complimented on the opening of the Baltimore and Ohio Railroad, at the Fairmount banquet, he characteristically replied, in part as follows :

“The merit which has caused my name to be mentioned in this connection, would doubtless have been exhibited to the same extent by any other professional man, who had the same opportunity of constructing a similar road over such a country. The general maps indicated the courses of the streams that were to facilitate the work ; but where the mountains were to be crossed and tunnelled, and the rivers to be spanned, was a matter of careful examination, in which I was aided by the talent and perseverance of skilful assistants, whose valuable services I shall always take pleasure in acknowledging.”

In another place he says : “In crossing or tunnelling the mountains, and spanning the rivers, sometimes one

plan had to be adopted and sometimes another, and I have been constantly surrounded by able and accomplished assistants, to whom I take pleasure in according their share of whatever merit there may be found in the task I have accomplished."

A less sanguine temperament than that possessed by Mr. Latrobe would have recoiled from the task he saw before him, but its very difficulties seemed to give the work new attractions.

These works, from the Chesapeake to the Ohio, are a noble monument to his professional skill and indomitable perseverance.



Henry Green
Obituary

COLONEL CHARLES ELLET, JR.,

CIVIL AND MILITARY ENGINEER.

THE public services of Charles Ellet, Jr., have not received the general recognition and appreciation they so highly merit. The Engineering profession in this country has never had a more industrious worker, or intelligent and original thinker. His vigorous mind challenged, with the greatest satisfaction, enterprises of a bold and difficult character. His views were broad and far-seeing; his judgment on matters pertaining to his profession, aided by his superior mathematical knowledge, was rarely at fault, although his opinions were often in advance of the times.

Work, persistent and unflagging, with brain and hand, was the means he used for attaining success, and no amount of discouragement or opposition with which he might be confronted, would deter him from pursuing his object, no matter how remote the end might at first seem to be. He was impatient of opposition, bearing down all objections by a torrent of argument, sustained by the most exact logical and mathematical deductions.

His career was full of interesting incidents, a few only of which can be embodied in this sketch, too brief to satisfy the desires of the compiler.

Charles Ellet, Jr., was born January first, eighteen hundred and ten, at Penn's Manor, Bucks County, Pennsylvania, within five miles of Bristol. Destined by his father to the life of a farmer, he received, in common with the children of his large family, the plain English education afforded by the country grammar schools of the time, and no other, with the exception of a few months' attendance upon a day-school in Philadelphia. He gave evidence, from an early period, of mental development, of the great mathematical talent for which he was afterwards distinguished, and at the age of fourteen or fifteen he began that insatiable pursuit of knowledge which enabled him, through many difficulties, to stock his ready mind and retentive memory with an extraordinary amount of information. At this period of his life he studied at every opportunity, hiding his books beneath his pillow in sickness, and carrying them with him to the plough and the harvest field. While thus eager after knowledge, he was conspicuous among the youth of his community for skill, agility and strength, and tales are still told of his daring feats, by those who knew him in his early days.

At the age of seventeen, young Ellet left home to serve for a few months as rodman, in a survey then being conducted by Canvass White, along the north branch of the Susquehanna, where he acquired the rudiments of his profession.

In eighteen hundred and twenty-eight he was appointed by Judge Wright, then Chief Engineer of the Chesapeake and Ohio Canal, to act as volunteer assistant, without any fixed position or salary. In this capacity he did

almost all the office work of his party, drawing the maps and making the computations, almost without assistance, after walking from ten to twenty miles a day surveying, and fording the Potomac river in many places. He soon received from Judge Wright, as a recognition of his services, the position of Assistant Engineer of the Fifth Residency, under the supposition, afterwards admitted, that he was at least twenty-two years of age, and had considerable experience in engineering. During the whole period of his connection with the Chesapeake and Ohio Canal, he devoted every leisure hour to the prosecution of his studies, especially in the languages, for which he had a marked talent, and acquired command of several.

In two years, by great economy and self-denial, young Ellet had set aside from his slender salary a sufficient sum to enable him to go abroad and complete his education in Paris, where he spent the winter of eighteen hundred and thirty-thirty-one in close study, and in following the course of the *Ecole Polytechnique*. The knowledge of French which enabled him to do this had been gained since he left his home, in eighteen hundred and twenty-seven. He had the entrée into the most intellectual and interesting French society, where he was received in a very flattering manner. He declined all social overtures for the sake of his studies, with the exception of the kind attention of General Lafayette, whose interest in him was very marked, and who talked with him much of the political condition of France, and foretold to him the Revolution "*Des Trois Tours*" (which he witnessed within a

week of the prediction), unless his Majesty "Charles the Tenth" should change his policy."

By husbanding every resource he made his small stock of money last through a year, during which time he visited England, and also travelled on foot through France and much of Germany, carefully examining the public works of these countries. He calculated his means so closely that on his journey home he was forced to sell many of his treasured books and instruments.

In eighteen hundred and thirty-two, when only twenty-two years of age, with a boldness and originality of thought and action, by which his whole professional career was so strongly characterized, he proposed to Congress a plan for the erection of a wire suspension bridge across the Potomac, of one thousand feet span. The novelty of the plan presented, and at a time, too, when the practicability of works of this nature had been demonstrated only in the mind of the Engineer, and the general principles of the subject so little known and understood by the public, met with no encouragement in the National Legislature.

In the summer of eighteen hundred and thirty-three he was engaged as Assistant Engineer in the location of the western division of the Utica and Schenectady Railroad, now part of the New York Central, under William C. Young, Chief Engineer.

The first survey of the western division of the New York and Erie Railroad (present Erie Railway) was conducted by him in eighteen hundred and thirty-four, and it is worthy of note that when, after being discontinued for several years, this enterprise was resumed, and the Engi-

neers in charge endeavored to find a more favorable location, after an expenditure of much time and money upon other surveys, they fixed finally upon the line located by Ellet through the wilderness of Western New York, in the early part of his professional career.

In eighteen hundred and thirty-five he entered the service of the James River and Kanawha Canal Company, as Assistant, and was very soon appointed Chief Engineer of the entire work.

In compliance with a resolution of the Board of Directors he made, during the next year, a very able report on a survey for a ship canal from Richmond to Warwick, and presented a plan for the connection of the James River and Kanawha Improvement with tide water. He recommended the construction of a canal four and one-third miles in length, to extend from a basin to be raised by the construction of a dam across the river, below Mayo's Bridge, through the low grounds on the south side of James river, to the deep water at Warwick. The dimensions of the canal proposed were : width at surface one hundred and twenty feet, and at the bottom fifty-two feet, and seventeen feet deep. This was thought to be amply sufficient for the passage of the largest ships of that time from tide water to the wharves at Richmond.

His reasons for the construction of a canal instead of attempting to remove the obstructions between Rocketts and Warwick, and using the bed of the river, are clear and philosophical : "The bars, which are deposited at the head of tide, are formed by the materials brought down by the streams from the interior of the country, and they

consist, in fact, of the waste of the whole district drained by the tributaries of the river, at the mouth of which the material subsides. This matter is loosened by the action of rains, and moved by the current, the heavier particles subsiding as the transporting power of the water diminishes, while the lighter are swept on and contribute to the formation of bars at the head of tide, and of deltas at the mouth of the streams. The deposit is greatest where the diminution of the fall of the river is most abrupt, and the resistance to the motion of the water is greatest, and, consequently, on approaching tide water, where the transporting power of the river is suddenly neutralized, much of the matter which was forced along the bottom is left by the current, and of that which was held in suspension, much is precipitated.

“The wearing away of the upland is unceasing, and the process of transportation is not less constant, and no plan for the navigation at the points where the resistance of the material which is deposited is superior to the tidal force, can be perfect which does not provide for the disposal of this matter.

“The objection, then, to the project of a dam below shoal water, and raising the surface from that point up to Richmond a sufficient height to float the shipping that can come to Warwick, is, that instead of disposing of this material, we prepare calm water to destroy the force of the current, and a basin to receive the sediment that is precipitated. We have not the necessary data to determine the time that would be required to fill this basin, so as to again interfere with the navigation of the pond ; but when

we observe the great quantity of sediment that is discharged by the river at every freshet, and know that the deposit would occur chiefly above this dam, and that it would continue to increase until the depth of water would be reduced to the point where the transporting power would again become superior to the resistance, we shall appreciate the uncertainty of the expedient."

During the four years of his connection with this Canal Company he wrote many excellent pamphlets, reports, and articles for the public press, chiefly on topics relating to the improvement and prosperity of the State of Virginia ; and forcibly advocated a continuous line of improvements, extending from the Atlantic Ocean to the Ohio river, an enterprise now being consummated in the construction of the Chesapeake and Ohio Railroad.

While engaged upon this work, he married, in eighteen hundred and thirty-seven, Miss Daniel, daughter of Judge William Daniel, of Lynchburgh, Virginia, who proved a partner in every way worthy of her husband.

On retiring from the service of the James River and Kanawha Company, in eighteen hundred and thirty-nine, he returned to Philadelphia, where he published in the same year an "Essay on the Laws of Trade," a work of two hundred and eighty-two pages, devoted to the works of internal improvement in the United States. The subject of railroad, canal, and river transportation, was thoroughly examined and discussed. American internal improvement was then but in its initiative stage ; yet with remarkable judgment and keen perception he forecast the sources and lines of trade, as since developed ; the tonnage and cost

of transportation ; the sources of economy, and the causes from which failure might be apprehended. He earnestly advocated, and gave his reasons, which have been very generally verified by railroad practice, both in this country and in Europe, *for a low rate of speed in the movement of heavy freight trains, the use of heavier locomotives, and the construction of the most perfect and permanent road bed and superstructure.*

This work attracted much attention at the time, and was extensively read by statesmen, economists, and managers of railway and canal enterprises, and may, at the present day, be found profitable reading by the same class of public men.

In the same year he published his "Popular Exposition of the Incorrectness of the Tariffs of Toll in use on the Public Improvements of the United States," in which he "endeavors to demonstrate the incorrectness of the tariffs of toll in common use on the canals and railroads of this country, and to point out a method of assessing the charges on heavy tonnage, which will be the means of securing the highest revenue, and of rendering the tax on the public most equitable."

During the next few years Mr. Ellet gave to the Council of the city of St. Louis, a design and report for a suspension bridge across the Mississippi river at that city ; was employed to survey the city and county of Philadelphia ; paid a visit of some months to Cuba with a view to the restoration of his health, then so much impaired as never to be permanently restored ; and issued a number of publications referring mainly to the railroads of the

United States, their tariffs, and the causes which conduced to their general want of prosperity. The following extracts will give, as briefly as can be condensed, his opinions on these subjects. After remarking, "there are completed, or in progress of construction,* between three and four thousand miles of railroads in the United States, on which have been expended more than one hundred millions of dollars," he says:—

"Of these works some few have thus far sustained themselves, and distributed considerable dividends; the receipts of some others are sufficient to keep them in repair, and pay the interest on the loans incurred for their construction, but the balance, having an aggregate length of some two thousand miles—the capitals may be regarded as positively sunk, and many of the companies as insolvent."

In his opinion "this disastrous result is not the consequence of attempting improvements in positions where trade and travel were insufficient to authorize the necessary outlay of capital; but proceeds from the fatal practice of imitation, and a thorough disrespect of first principles."

"The roads constructed by these unfortunate companies, instead of being such as appeared to be justified by the condition of the country in which they are situated, were only such as the Engineer, or President, or leading stockholders, had somewhere seen or read about. In the beginning there was no particular object proposed to be attained; and in the progress of the work, there was

* 1841.

nothing to rule the general plans, or govern the arrangement of the detail—and they failed, of course."

"The object of a railroad is to convey passengers and freight, and the first questions which every company about to embark in such an enterprise, should propose for examination is, What is the amount of trade and travel to be accommodated? for this amount furnishes us the value of the object sought by the improvement, and ought to prevent us from paying more for it than it is worth; and the second is, What should be the location and character of the road, and the character of its furniture, for the economical accommodation of the trade which it is found may reasonably be anticipated." * * * * *

"The amount of trade to be accommodated has never yet governed the plan, location, and execution of any public work. All such enterprises in this country, and indeed nearly all the railroads in the world, bear one common impress, and every important sign of imitation of one common standard. They are all struck, as it were, with the same die, and belong to the same set. The same width of track, the same strength of rail, engines of the same weight, and cars of the same magnitude, prevail on the roads between the great cities, which carry half a million of tons, and some hundreds of thousands of passengers every year, and those of the obscurest districts of the United States, where as many persons and as much trade will scarcely be witnessed in the course of half a century."

"This imitation is universal. The same powerful engine, with its vast cars, is driven when loaded with a

hundred tons of freight, or more than a hundred passengers, as when conveying its mere 'tender' and empty train. It is so universal that the expenses of transportation are now frequently estimated, by ascertaining the number of times the engine passes over the line, without reference at all to the load which it draws. The error consists simply in providing a power too great for the business to be done."

"They make costly roads, build expensive superstructures, rear extravagant edifices, to contain their cars and engines, run heavy locomotives, and use carriages almost as capacious as dwelling-houses, to carry as many passengers as could, without much inconvenience, be drawn in a hand-cart."

"*If railroads do not sustain themselves it is not because they are railroads, but because great roads have been constructed where little ones only are required.* I do not believe that there has been such a work commenced, nor probably authorized, which could not pay a liberal and honest dividend, if the road, stock, and entire apparatus were duly proportioned to the duty to be performed." In making a homely comparison, he says: "The power contrived to drive a grist-mill, would make but small dividends if applied to turn a churn."

In further explanation of his views of railway economy, he remarks: "It is far from my object to advocate the exclusive employment of cheap roads, and light stock; my intention is only to recommend them as I would a light carriage, or light machine, when true economy, convenience, and comfort dictate their adoption. A

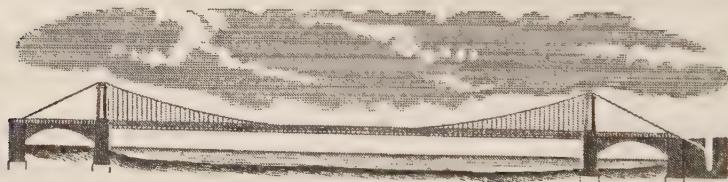
large business will demand more extensive preparations."

* * * An increase of business will give rise to improvements in the system adequate to its wants.

* * * When the business created by a population of many millions has to be transacted along a line of canal or railroad, every resource that can be obtained from the increasing application of science and art, will be brought in requisition." * * * *

In eighteen hundred and forty-one and two, he designed and constructed the wire suspension bridge across the Schuylkill at Fairmount, the first structure of its kind in this country, and considered at the time a triumph of engineering skill.

This bridge still remains in good condition, after a service of thirty years of constant use, and is justly regarded with feelings of pride by the city of Philadelphia. Its destruction would be the removal of one of the most interesting landmarks of that city.



FAIRMOUNT BRIDGE.

After a second visit to Europe, Colonel Ellet engaged in the well-remembered controversy between the Schuylkill Navigation Company and the Reading Railroad. The discussion was carried on through the public press, and by circulars and pamphlets, and was conducted with much earnestness on both sides, and in which he fully

established his reputation as a most forcible and unsparing writer.

In eighteen hundred and forty-six, he was chosen President of the Schuylkill Navigation Company, in which he was a large stockholder, and although in feeble health, and greatly hampered by strong opposition, he accomplished an almost incredible amount of labor.

The navigation was increased from a canal of a very irregular and contracted area to one averaging more than seventy feet in width ; from a depth of four feet to six feet, and from a capacity for boats of sixty tons to not less than one hundred and eighty tons burthen. Seventy-one locks, one hundred and eighteen feet long by eighteen feet wide, and eleven stop gates, were built ; twenty-five culverts were lengthened, and four new ones built ; ten aqueducts were raised, improved, and strengthened ; eighty-two bridges were raised, and seventy-four new ones built ; twenty-two dams were permanently raised ; two new channels were cut for the river ; eleven new guard locks were built, and many of the old ones raised and strengthened ; one hundred and twenty boats and scows, and one hundred and fifty additional cars, were constructed, besides many changes and enlargements made in waste weirs, sluices, and tow-paths.

In charge of divisions, Colonel Ellet had to assist him in arranging and carrying out his plans, Ellwood Morris, Antes Snyder, and James F. Smith, Civil Engineers of skill and experience.

The author, while engaged in locating the Great Western Railway of Canada, and what is now the Rochester

and Niagara Falls branch of the New York Central Railroad, proposed to connect them by a railway suspension bridge over the Niagara river, between the Falls and the "Whirlpool," where the chasm was about eight hundred feet wide, and over two hundred feet deep. As the project was a novel and bold undertaking, and generally believed to be impracticable, a circular letter was addressed to a number of the leading Engineers of America and Europe, asking their opinion of the undertaking. Various replies were received, some in open condemnation of the project, others expressive of grave doubts of its practicability and safety at any cost.

Charles Ellet, Jr., John A. Roebling, Samuel Keefer, and Edward W. Serrell, alone favored the project, and it is a somewhat remarkable coincident that each of these Engineers have since constructed a suspension bridge over the Niagara river, below the Falls, thus demonstrating the accuracy of their early faith. The following letter was received from Colonel Ellet, dated Philadelphia, October twelfth, eighteen hundred and forty-five :

"In the case which you have presented, I can, however, say this much with all confidence : A bridge may be built across the Niagara below the Falls, which will be entirely secure, and in all respects fitted for railroad uses. It will be safe for the passage of locomotive engines and freight trains, and adapted to any purpose for which it is likely to be applied. But to be successful it must be judiciously designed, and properly put together ; there are no safer bridges than those on the suspension principle, if built understandingly, and none more dangerous if constructed

with an imperfect knowledge of the principles of their equilibrium. To build a bridge at Niagara has long been a favorite scheme of mine. Some twelve years ago I went to inspect the location, with a view to satisfy myself of its practicability, and I have never lost sight of the project since. I do not know in the whole circle of professional schemes a single project which it would gratify me so much to conduct to completion."

In eighteen hundred and forty-six a Company was chartered by the Legislature of New York to construct a bridge over the Niagara river, at or near the Falls, with power to connect with any other Company for that purpose. A charter with similar provisions was granted to a Company in Canada by the Provincial Parliament, and approved by the Home Government. After repeated efforts, made during this and the following year, subscriptions to the capital stock, sufficient to warrant the commencement of the work, were secured, and soon thereafter plans and estimates were invited. The following letter relating to the subject was written by Colonel Ellet, dated Philadelphia, February thirteenth, eighteen hundred and forty-seven :

CHARLES B. STUART,

Commissioner of the Niagara Bridge Company.

DEAR SIR,—I promised to give you my views of the practicability and probable cost of the proposed bridge across Niagara river below the Falls. Immediately after inspecting the site, in eighteen hundred and forty-five, I gave the whole subject a careful investigation, and made a

fair, but not extravagant, estimate of the cost of such a structure as I thought would be appropriate and of adequate strength.

This estimate amounted to two hundred and twenty thousand dollars for a railroad bridge competent to sustain the weight of locomotive engines and heavy freight trains, and one hundred and ninety thousand dollars for one suitable for common travel, with a railway track in the centre, to be crossed by passenger and burthen cars drawn by horses.

When I made my estimate, I had in view a work of the first order, and as I do not wish to be in any way connected with one of a lower grade, I cannot offer to reduce my proposition. But I will now repeat, that a secure, substantial and beautiful edifice, not one, however, equal to the claim of the locality—for nothing can match that—but a noble work of art, which will form a safe and sufficient connection between the great Canadian and the New York railways, and stand firm for ages, may be erected over the Niagara river for the latter sum named. If it should be built by me, or under my charge, it will cost about that sum, and I trust it will be worth the money.

With my best wishes for the success of the enterprise in all its magnificence,

I remain dear sir,

Yours truly,

CHARLES ELLET, Jr.,

Civil Engineer.

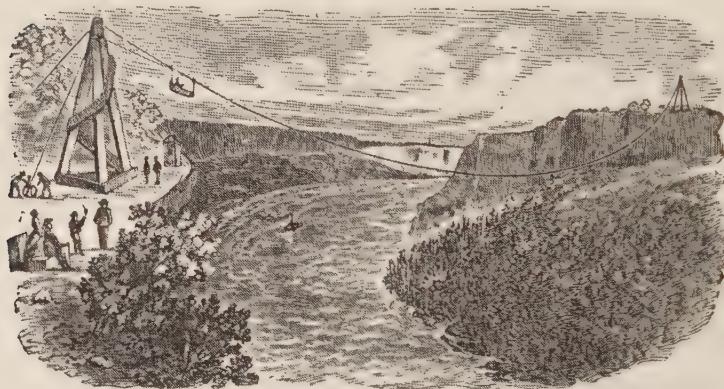
On the ninth of November, eighteen hundred and forty-seven, the Directors of the American and the Canadian Niagara Bridge Companies made a contract with Charles Ellet, Jr., for the construction of a railway and carriage bridge over the Niagara river, two miles below the Falls, for the sum of one hundred and ninety thousand dollars. The span was to be about eight hundred feet, and twenty-eight feet in width between parapets, divided as follows: Two carriage-ways, each seven and one-half feet, two foot-ways, each four feet wide, and one railway track in the centre of the floor. Ultimate strength of cables, six thousand five hundred tons. Trains not to exceed twenty-four tons, to be drawn by a locomotive of about six tons weight. The towers to be of stone. The bridge to be tested to two hundred tons, and to be completed by May first, eighteen hundred and forty-nine.

The work was commenced early in the following spring, by the erection of a light structure of nine feet wide, to be used as a service bridge in the erection of the main work, and was also used for a foot-bridge for ten months after its completion in the following July. Its cost was about thirty thousand dollars, and the tolls received during this time amounted to nearly five thousand dollars, notwithstanding the constant interruption to travel by the progress of the work. This bridge was strengthened in the summer of eighteen hundred and forty-eight sufficient to accommodate the ordinary travel of the country until the completion of the present railway bridge in eighteen hundred and fifty-five.

In the summer of eighteen hundred and forty-eight, a

difference arose between the contractor and the Directors, respecting the application of the tolls taken on the foot-bridge, which, after some litigation, ended by a compromise, by which Ellet relinquished his contract; and his connection with the work terminated on the twenty-seventh of December, eighteen hundred and forty-eight.

The following letter describes the *first basket ride* over the *Niagara* by the daring engineer, a faithful sketch of which is given in the accompanying engraving.



ELLET'S BASKET-RIDE OVER NIAGARA RIVER.

NIAGARA FALLS, *March 13th, 1848.*

CHARLES B. STUART.

DEAR SIR,—I raised my first little wire cable on Saturday, and anchored it securely both in Canada and New York. To-day (Monday) I tightened it up, and suspended below it an iron basket which I had caused to be prepared for the purpose, and which is attached by pulleys playing along the top of the cable.

In this little machine I crossed over to Canada,

exchanged salutations with our friends there, and returned again, all in fifteen minutes.

The wind was high and the weather cold, but yet the trip was a very interesting one to me—perched up as I was two hundred and forty feet above the Rapids, and viewing from the centre of the river one of the sublimest prospects which nature has prepared on this globe of ours.

My little machine did not work as smoothly as I wished, but in the course of this week I will have it so adjusted that anybody may cross in safety.

Truly yours,

CHARLES ELLET, JR.

In eighteen hundred and forty-seven and eight Colonel Ellet constructed a wire suspension bridge across the Ohio river at Wheeling, remarkable at the time as the longest span in the world—one thousand and ten feet. This bridge was built for a roadway and foot-bridge; was twenty-four feet wide, and ninety-seven feet above the low water in the river. The weight of the bridge was nine hundred and twenty pounds per lineal foot, supported by twelve cables, six on each side, with an aggregate number of wires of six thousand six hundred, number ten, Birmingham gauge. This bridge was destroyed on the seventeenth of May, eighteen hundred and fifty-four, by a violent tempest of wind. The floor was torn by the force of the wind into three sections; the eastern portion measured five hundred feet, the western three hundred feet, leaving the central part about two hundred feet long. All the cables but two broke in succession from the anchorage; one cable, composed of one hundred and fifty wires, broke in the centre.

In eighteen hundred and forty-nine Colonel Ellet made a very elaborate report on a railroad suspension bridge across the Connecticut river at Middletown, in which he discussed with much minuteness the whole subject of this class of bridges. The span he proposed was one thousand and fifty feet; the floor elevated one hundred and forty feet above the surface of the water.

The same year he proposed to construct a suspension bridge across the Ohio at Cincinnati, with a single span of one thousand four hundred feet, at an elevation of one hundred and twelve feet. The proposed height of the towers was two hundred and thirty feet above low water, the floor to be suspended from twenty wire cables, each four inches in diameter—deflection one hundred feet, width twenty-six feet, permanent weight of bridge eight hundred and twelve tons, moving load four hundred and fifty tons, or six hundred and forty-three pounds per lineal foot; estimated cost, three hundred thousand dollars.

This was his second offer to construct this work, in reference to which he remarks: "It is now nine years since I gave formal assurance to many of your citizens that it was quite within the present state of art and mechanical knowledge, to throw a bridge over the Ohio which should offer no obstruction to the current, nor appreciable impediment to the navigation. I cannot say that further experience has strengthened that opinion, for the fact was susceptible of absolute proof then."

In the same year he contributed to the Smithsonian Institute a very interesting and valuable manuscript, on

the physical geography of the Mississippi Valley, with suggestions for the improvement of the navigation of the Ohio and other rivers.

In eighteen hundred and fifty, Colonel Ellet was appointed Chief Engineer of the Hempfield Railroad, a short but important line, connecting the city of Wheeling with the Pennsylvania Railroad, at Greensburg. While thus engaged, he conducted, on the part of the city of Wheeling, the controversy in regard to the location of the western division of the Baltimore and Ohio Railroad, and published two reports in which he supported the "Grave Creek route," over the "Fisk Creek route."

Colonel Ellet passed the winter of eighteen hundred and forty-nine and fifty, in Washington, in the endeavor to obtain from Congress a small appropriation for the purpose of testing a plan for the improvement of the Mississippi and Ohio rivers, by means of reservoirs, which had become a favorite project of his life. The bill passed the Senate, but was defeated at the last moment, in the House. He then accepted an appointment from Mr. Conrad, Secretary of War, to examine into the floods of the Mississippi river, and report upon their causes, as well as some plan for the prevention of their destructive influence. He spent the winter of eighteen hundred and fifty-fifty-one, in a close examination of the Lower Mississippi, its channels and deltas, and made many original observations upon the formation of the bars at the mouth of the river. He gave the results of his labors in a report to the War Department. This report he afterwards incorporated with his "Memoir on the Ohio River,"

printed by the Smithsonian Institute, entitled, "Ellet on the Mississippi and Ohio Rivers." This work presents, with its author's beauty of style, and originality of thought, the plan which was, in his estimation, the crowning conception of his professional career, that on which he rested his hopes of future fame. It was to this plan of improving the navigation of the great rivers of the country, by means of vast reservoirs erected at their head-waters, by which the surplus water of the seasons of floods might be stored up, to be set free in the droughts of summer, that he devoted his most earnest thought, until his interest was diverted from every subject connected with his profession, by the political difficulties of the country. It was certain that one feature of this comprehensive plan, which rendered it so captivating to Colonel Ellet's mind and heart, was its general utility to the whole country, tending by its wide-spread benefits, to draw more closely the bonds between the North and South.

In eighteen hundred and fifty-three Colonel Ellet accepted the position of Chief Engineer of the Central Virginia Railroad, and, during a connection of some years with this work, had occasion to familiarize himself thoroughly with the public improvements of the State of Virginia, in regard to many of which he was consulted. In order to bring this road into immediate use, while waiting for the completion of a long tunnel through the Blue Ridge, he constructed a temporary track across the mountain at Rock Fisk Gap, which, from its steep grades and sharp curves, attracted considerable attention from Engineers at home and abroad. Maximum grade two hun-

dred and ninety-six feet per mile. Least radius of curvature two hundred and thirty-four feet.

In eighteen hundred and fifty-two he offered, in response to a call from the citizens of Georgetown, a second plan and report for a suspension bridge across the Potomac river.

Colonel Ellet passed the years of eighteen hundred and fifty-four and fifty-five in Europe, partly in the service of the Virginia Central Railroad, and partly on account of his health. He took a lively interest in the Crimean War; and when the Russian fleet was closely blockaded by the Allies in the harbor of Sebastopol he perfected a plan for destroying ships of war by means of steam rams, already suggested by observations upon the usual results of collisions at sea, and offered it to the Russian Government at a time when, if adopted, it must have resulted in the destruction of the entire Allied fleet. Before returning to the United States, and immediately afterwards, in view of the possible contingency of a war with Great Britain, Colonel Ellet wrote several letters to the Secretary of the Navy, urging his plan upon the Department, but, failing to attract other attention than a courteous acknowledgment, he issued in eighteen hundred and fifty-five a pamphlet, entitled "Coast and Harbor Defences, or the Substitution of Steam Battering Rams for Ships of War," addressed to Congress, which fully justifies his claim to be considered the author of this new mode of naval warfare. The pamphlet attracted much attention at the time, particularly in the Southern States, where Colonel Ellet was well known, and which were subsequently the

first to put his views into practice, and in a cause opposed to his patriotic sentiments and principles.

On his return from Europe, after a brief residence in Philadelphia and Richmond, in the service of the Virginia Central Railroad, he settled in Washington for the purpose of carrying a bill through Congress for an appropriation only sufficient to enable him to demonstrate, on a small scale, the practicability of his Reservoir plan for the improvement of the Mississippi river. He had, at the opening of the session, every hope of success; but Congress soon became so absorbed in the political questions of the day, that he found it impossible to accomplish his purpose. The bill passed the Senate, as before, and was lost in the House. He then retired to his country seat on the Heights of Georgetown, but was called from thence, in eighteen hundred and fifty-eight, to survey the Great Kanawha, with a view to ascertaining the applicability of his Reservoir system to the improvement of that river.

As early as the summer of eighteen hundred and sixty-one his attention was attracted by references in the Southern newspapers to certain vessels in course of construction in the harbors of Norfolk, Mobile, and New Orleans, and he became convinced that the rebels were putting into execution his plan for steam battering rams. He endeavored, by a series of letters to the Secretary of the Navy, to arouse the Department to a sense of the menacing danger, and, failing in this, a few weeks before the naval disaster in Hampton Roads, in his second pamphlet, he gave a startling warning in regard to the steamer Merrimac in words which might serve as a description of her subsequent deeds.

A few days after the battle of Hampton Roads, on the receipt of alarming telegrams from the West, Colonel Ellet was commissioned by the War Department to do what he could, speedily, to aid and protect the Mississippi gun-boat squadron against a fleet of rebel rams, understood to be advancing up the river. The need was too pressing to admit of the construction of boats. In six weeks Colonel Ellet had procured and so strengthened nine ordinary river steamboats as to serve temporarily as rams. Of this fleet he was placed in independent command, with the rank of Colonel, and proceeded at once with his unfinished and ill-protected wooden vessels down the river. Detained for some time above Fort Pillow by the unwillingness of Commodore Davis, commander of the gunboat squadron, to advance, he became so uneasy lest the rebels should desert Forts Pillow and Randolph, that he pushed down alone, and, taking possession of the forts, found his fears realized, the rebels having retired the preceding night.

On the sixth of June, eighteen hundred and sixty-two, the battle of Memphis was fought. Colonel Ellet had given orders that the Stars and Stripes at the mast-head of his flag-ship should be the signal to his little fleet to follow him at once into action. On that morning, at the first shot from the rebel fleet of iron-clad vessels and rams, Colonel Ellet hurried on deck of his vessel, the "Queen of the West," and waving his hat to his brother Alfred, who commanded the "Monarch," next in order, he caused his flag to be run up, and his vessel to bear down upon the foe. The "Monarch" alone obeyed the

signal, and, in presence of both fleets, and of the thousands of spectators who lined the shores, these two wooden boats passed through an iron squadron, and selecting two of the most prominent of the advancing fleet, ran them down. The two rebels boats sank—the one instantly, the other in a few moments—with all their living freight ; the "Monarch" was uninjured ; the "Queen of the West" received a blow which rendered it necessary for her, shortly, to go ashore. The results of the engagement were, that of the eight rebel boats, three were sunk outright by his two rams, two were captured, and one escaped below ; the remaining two were disabled by long shots, and captured by the gunboats. During the encounter with the enemy, Colonel Ellet became so much interested in the practical illustration of his theory, and so anxious to witness the result, that he again stepped out alone upon the deck, and received a pistol shot in the knee from the hand of some one on the sinking ship struck by the "Monarch." His wound was not, at first, deemed serious. He sent a number of despatches to the Secretary of War, continued in command of his fleet, and sent his young son, with three companions, before the firing had ceased, to demand the surrender of the city, and to replace the rebel flag upon the post-office by his own. The order was executed with great gallantry, in presence of a large and hostile crowd. In the course of a few days it became evident that his feeble frame could not resist the effects of a wound which would have proved fatal to a stronger constitution. Colonel Ellet was transferred from his flag-ship to the "Switzerland," and, even when sinking under the heat of

the climate, and assured by his physicians that his only hope of recovery lay in a prompt removal, he refused to have the vessel turned back for his accommodation until he ceased to notice external things, when his brother Alfred, who had taken temporary command, had the course of the boat directed up the river. He was taken to Cairo, at which point, on the twenty-first of June, eighteen hundred and sixty-two, surrounded by his family, who had been able to join him, he breathed his last, so peacefully that it was truly a "falling asleep."

Great as was his professional reputation and his fame as a soldier and patriot, it will never exceed the high regard in which he was held by those who were favored by his intimate acquaintance and friendship. Colonel Ellet possessed many sterling qualities. His whole conduct was governed by a high sense of integrity and honor. His friendship was reliable and unselfish. When wronged, his pride was quickly aroused, even to an appearance of conceit, which, however, could be attributed to strong convictions of being right, and a consciousness of superiority over those by whom he was unjustly treated.

In personal appearance Colonel Ellet was tall, spare in figure, but commanding in presence. His eyes dark and piercing, and when aroused in a controversy that called out the energies of his mind, his eloquence was like a mountain torrent, carrying away every opposing obstacle. In his domestic relations no one could have been more happy. His devotion to his excellent and accomplished wife knew no bounds, while his tenderness to his children was excessive.

His accomplished daughter writes : " As for the dear task of giving a sketch of my late father's domestic life, I am utterly unfit for it now. You, who knew him only as men could know, will yet understand, when I say that to me he is the embodiment of all that is noble, gentle, generous and great. You say rightly that, in the social and domestic sphere, he was as distinguished as in his professional life. He has left by his pen and his public works a record that must one day establish his fame before the world, but it was at home, as a parent, a husband, and a friend, that his superiority over other men was most manifest. Our household was truly, as I have often heard it called, a home of love. You must have known something of his devotion to my mother—a feeling the mainspring of his whole life—my mother, whose cheek he would not have the 'winds of heaven visit too roughly.' His tenderness to his children exceeded anything that I have ever known. Indifferent, almost averse, to society, he lived in his little home circle, his office was the family sitting-room, he wrote his most labored works and carried on his most abstruse calculations with his wife beside him, and his little children climbing on his chair. In sickness he was their kindest nurse, in every difficulty their tenderest friend—they played with him, sought his counsel, displayed for him each little accomplishment, and obeyed him with a passionate love that had in it little or nothing of fear.

" I do not think he ever expected to live through the war. At the very outset he made his will, as we subsequently learned, leaving everything he possessed to his

beloved wife, for the express purpose, as he states, of making their children dependent upon her for their means of support. I shall never forget one evening when I urged upon him the question of the unfortunate termination of the Union. At first he refused to consider such a possibility, and when I pressed it upon him he said, with a look that silenced me: '*At least I shall not live to see it.*'"

Colonel Ellet left two sons; the oldest, Charles Rivers Ellet, whose youth gave every promise of a brilliant manhood, was with his father at the battle of Memphis and won great credit. Immediately after his father's death he received the appointment of Colonel of the Ram Fleet, though barely eighteen years of age, and in that command achieved feats of gallantry which made his name and fame celebrated along the Mississippi, having run his wooden vessels twice past the batteries of Vicksburgh. His health was undermined by the climate, and he died at the early age of nineteen. The other son is a promising boy, still at school.

SAMUEL FORRER,

SURVEYOR AND CIVIL ENGINEER

SAMUEL FORRER was born in Dauphin County, Pennsylvania, January seventeenth, eighteen hundred and ninety-three. His parents, Christian and Elizabeth Forrer, were also natives of that State. When Samuel was three years old, his father removed to Virginia and purchased a large farm in the Shenandoah Valley. On this property there was a flouring and a saw-mill, to which his father added wool-carding machinery.

After receiving such an education as boys usually obtain in ordinary country schools, he was employed on the farm or in the mills, as necessity or inclination directed, and being of a mechanical turn of mind, he acquired considerable skill in mill-wright work and machine building, which afterwards was very useful to him in his profession as a civil engineer.

When twenty-one years of age he visited Ohio, but soon after returned home, where he remained until eighteen hundred and seventeen, when he removed to Dayton, Ohio, which has since been his place of residence.

In eighteen hundred and eighteen Mr. Forrer was appointed Deputy Surveyor of Hamilton County, Ohio, and

also Deputy Surveyor under Colonel Richard C. Anderson, Principal Surveyor of the Virginia Military District of Ohio. In this capacity he was employed during the winter of eighteen hundred and eighteen and nineteen, in surveying through the Wilderness the military lands north of the Greenville line, which service was attended with great labor and exposure. Mr. Forrer was not only one of the pioneer surveyors of Ohio, but has since and for many years been honorably identified with the engineering connected with the public works of that State. So early as eighteen hundred and twenty, Mr. Forrer made his first attempt at civil engineering by examining the summit between the Sciota and Sandusky rivers, to ascertain the feasibility of uniting the waters of Lake Erie and the Ohio river, by means of a navigable canal. This survey was made at the request and expense of William Steel, of Cincinnati, who communicated the result to the General Assembly of Ohio, which resulted in the appointment of a Board of Commissioners in eighteen hundred and twenty-two, with authority "to employ a competent and experienced engineer to make a survey and estimate for a canal to connect Lake Erie with the Ohio river."

The Hon. James Geddes, of the State of New York, was employed by the Board, with Isaac Jerome, an experienced engineer of that State, as Assistant. Mr. Forrer was advised by Governor Brown—one of the Board of Commissioners—to join the Engineer Corps in any situation that might offer. He accordingly accepted the position of a junior rodman, with a compensation of

only nine dollars per month. In a short time the senior rodman was taken ill, and left the party, when Mr. Forrer was advanced to his place. Soon thereafter Mr. Jerome was taken ill with the prevailing fever of the country and returned home, when Mr. Forrer was promoted to the position of Assistant Engineer, and during the two following years he was almost constantly engaged in running experimental lines for the canal.

In July, eighteen hundred and twenty-five, the Ohio canals were commenced under the charge of the Hon. David S. Bates as Chief Engineer. Mr. Forrer was employed as Resident Engineer in charge of the work on the Miami and Erie Canal. He continued in the service of the State until eighteen hundred and thirty-one, during which time he located the whole of the Miami and Erie Canal and its branches, and a great portion of the Ohio Canal.

In eighteen hundred and thirty-two Mr. Forrer was appointed a member of the Board of Canal Commissioners, and continued in that position three years. The Board was then abolished, and a Board of Public Works created in its stead by the Legislature of Ohio, of which he was a member for several years.

Not only was he exceedingly useful in this capacity, but by his zeal, general intelligence, and force of character, he contributed largely to the promotion of the canal system, and was a valuable co-laborer with the men of that period, who shaped the policy of the State and laid the foundations of her commercial institutions. With the present financial strength of Ohio—so great that the

annual tax for State expenses alone amount to nearly twenty-five millions of dollars, and the total valuation of taxable property twelve hundred millions—it can scarcely be conceived that as late as eighteen hundred and twenty-two the Board of Commissioners deemed it necessary to inquire, in the gravest manner, of the highest financial authorities in New York, if in all the money markets of the world a loan of three millions of dollars, for thirty years, on the pledged faith of the State, could be negotiated for the purpose of connecting the Lakes with the Ohio river.

In eighteen hundred and thirty-eight Mr. Forrer was appointed by the State of Indiana Consulting Engineer, with Sylvester Welch, then Chief Engineer of the State of Kentucky, for the consideration of important engineering questions connected with a general system of internal improvements, contemplated by that State. Their report and recommendations were adopted by the State Legislature, and the works constructed in accordance therewith.

Mr. Forrer's sound judgment, practical sense, and high reputation for probity and fairness, induced the reference to him for decision of many questions of a professional nature, not only in Ohio, but in adjoining States. His decision and advice were usually the end of a controversy.

In eighteen hundred and forty-nine Mr. Forrer was for some time engaged in making the surveys for the location of the Ohio Central Railroad, from Zanesville to Wheeling, through a country, although not mountainous, yet so broken into hills and valleys, many of them of consider-

able magnitude, as to require great skill and judgment in selecting the most favorable route. Mr. Forrer greatly excelled as a Locating Engineer, a duty more suited to his tastes and talents than the details of construction. Those most familiar with his qualifications have expressed the opinion that, in the peculiar trait which grasps almost intuitively the topographical formation of a region of country, its capabilities and possibilities for a canal or railroad location, Mr. Forrer had no superior.

In the projection of several of the railroads in the western part of Ohio, centring at Dayton, Mr. Forrer was engaged in their preliminary surveys and locations, and rendered important service in shaping and giving direction to those improvements. He was uniformly esteemed as a safe and reliable engineer, and as such exercised a controlling influence in all general movements in regard to many of the early public works of the West.

Mr. Forrer also located several turnpikes leading out of Dayton and Cincinnati, and in other parts of Ohio. He was at one time a contractor on the Wabash Canal, in Indiana, and also on the Pacific Railroad in Missouri. He was always noted for his agreeable and attractive social qualities, and his manly bearing. His manners, though plain, were characterized by great dignity and gentleness. His nature is full of kindness and benevolence. Sickness and suffering, so common in the families of laborers on the public works in the West, during their construction, never met his observation without an effort for its relief. He could frequently be seen in the rude and transient abodes of the laborers, relieving their afflict-

tions by his sympathy and bounty. Generosity is a marked trait in his character, as shown in his large contributions to charitable objects, and liberal aid to relatives and friends.

It is generally deemed presumptuous to portray the character of the living, or anticipate their position with posterity. There are, however, exceptions to this rule. Of this number may be ranked the subject of this sketch, who, at nearly fourscore years, has retired from the active duties of his profession, to accept the responsible and honorable position of Consulting Engineer to the Board of Public Works of his adopted State.

The following letter from the Hon. Jesse L. Williams, of Fort Wayne, Indiana, dated Dayton, Ohio, April twelfth, eighteen hundred and seventy-one, explains itself, and will be a sufficient apology for its introduction here :

“ I was to-day an hour with Mr. Samuel Forrer at his house. He is in a feeble state. Paralysis has been gradually coming on, which affects somewhat his speech and strength of body. Yet his intellect is unimpaired. He is still the Consulting Engineer, and chief dependence, professionally, of the Ohio State Board of Public Works, especially as to everything relating to the Miami and Erie Canal, for the enlargement of which work he has lately submitted an estimate. He attends all meetings of the Board at Columbus. His age is seventy-eight years. I was gratified in having an opportunity, probably the last one, of conversing with so good a man, so near the close of a useful life.”

Several circumstances have prevented the collection of

many interesting incidents in the history of this very worthy Engineer, but the compiler of these pages relating to him has much satisfaction in making this brief record of a life so honorably and usefully spent.

WILLIAM STUART WATSON,

CIVIL ENGINEER.

THE utility of the Civil Engineer in promoting the advancement of civilization, and the progress of commercial convenience and social comfort, is an accepted reality. By his aid the canal and railroad have advanced our "Star of Empire" beyond the frontier that bounds our growing civilization, and shortened, by improved methods of transit, our old lines of commerce, and opened new ones, and through his skill devised the elegant comfort enjoyed by the modern traveller.

Though still below the middle age of life, Mr. Watson has borne a full share of the duties belonging to his profession. From the simple duty of rodman he has steadily risen through the various grades of Assistant, Chief, and Consulting Engineer.

William Stuart Watson was born in Dumfries, Scotland, on the fourteenth day of March, eighteen hundred and twenty-seven, and commenced his education with a view to his future profession, at Aberdeen. When twelve years of age he came with his father to this country, and settled with the family in Miami County, in the State of Ohio. His father remained in this country but a few years,

returning with his family, excepting William Stuart, to take possession of a valuable property which he inherited on the death of his father in eighteen hundred and forty-six.

Mr. Watson commenced his professional life at the early age of sixteen, as rodman on the Ohio canals, one of the schools which have given us many of our most accomplished Civil Engineers.

In eighteen hundred and forty-eight, then an Assistant Engineer, he returned to Scotland, and remained at his ancestral home for several months. On his return to this country he secured employment under that sterling man and eminent Engineer, Daniel Marsh, on the Genesee Valley Canal, where he remained until eighteen hundred and fifty, when he removed to Buffalo, and was engaged as Assistant Engineer on the Erie Canal enlargement.

The following year he was employed as Assistant by William Wallace, Chief Engineer of the Buffalo and Lake Huron Railroad ; and in eighteen hundred and fifty-two, in the same capacity, under the late Rosewell G. Benedict, on the Great Western Railway of Canada.

In eighteen hundred and fifty-three, being then but twenty-six years old, he received the appointment of Chief Engineer of the Baltimore and Pittsburgh Railroad. After making the preliminary surveys of a route for this railroad, he was induced to accompany Theodore D. Judah, a young Engineer of great promise, since deceased, then Chief Engineer of the Pacific Railroad, to California, in the capacity of First Assistant, where he aided in making the first surveys of the present railroad route to the

Pacific. At the close of this survey he received the appointment of Chief Engineer of the Placer Company Canal. On the successful completion of this work he entered the service of the Frenchtown Canal Company in the same capacity.

From eighteen hundred and fifty-four to eighteen hundred and sixty-eight, besides occupying the position of Chief Engineer on the California Northern, Sacramento Valley, California Central, Yuba, San Francisco and Central Pacific, San Francisco and Humboldt Bay, and Stockton and Copperopolis railroads, he had charge, as Chief or Consulting Engineer, of nearly all the large mining canals, aggregating several thousand miles in length, and costing many millions of dollars, in the northern part of the State.

Successful, as he invariably has been, as a railroad engineer, his greatest achievements have been in hydraulic mining works. Many of these exhibit an originality of design and boldness of execution, such only as the singular topography of that wonderful State of mountains and minerals could demand.

The works of the North Fork Hydraulic Company, five miles in length, were constructed by him in eighteen hundred and fifty-seven. About ten thousand feet of this construction is of wrought-iron pipe twenty inches in diameter, carried through a mountain gap nine hundred and twelve feet deep, and conveying two million two hundred and forty thousand cubic feet of water in twenty-four hours. The Cascade Canal Company's works, another of his successful engineering enterprises, is twelve miles

in length, with six miles of flumes. This canal is carried through one of the most formidable cañons in the State; and portions of the aqueduct, and some of the flumes, are suspended along the rocky sides of the stream, three hundred feet above the water.

In eighteen hundred and fifty-eight he carried out successfully an enterprise for the California Fluming Company. This project consisted in emptying the bed of Feather river, a mile in length, one hundred and twenty-two feet wide at low water, and forty-six feet deep, by the means of dams and flumes. The main dam was three hundred and twelve feet long on top, and ninety-seven feet long on the bed of the stream. It was constructed of a crib work of timber filled with stone. A flume was built one mile in length, forty-seven feet wide and ten feet deep, and contained two million five hundred thousand feet of lumber, and discharged for a period of ninety-four days, twenty-nine million seven hundred and seventy-nine thousand two hundred cubic feet of water per hour. The portion of the river, the bed of which was to be mined (one mile in length), was pumped dry by chain pumps worked by undershot wheels thirty feet in diameter, driven by the water in the main flume, the current of which moved at the rate of twelve miles per hour. The time occupied in removing the water was fourteen and one-half days. The "working out" of this portion of the bed of the river required the labor of six hundred men for thirty-one days. The total cost of this project was three hundred and sixteen thousand dollars.

Mr. Watson's latest engineering exploit was completed

on the last day of December, eighteen hundred and seventy. This work presents some novel features, and required an accurate knowledge of the laws that govern Hydrodynamics, and great skill and caution in its construction.

The object was to furnish water from the Feather river, for mining operations at Cherokee, in Butre County, California. The topography of the country presented some very formidable obstacles to be overcome.

The Cherokee mines consist of a considerable portion of a bed of auriferous washed gravel, one hundred feet deep, underlying trap rock, and is about eighteen miles in length by six miles in breadth, and lies at an elevation of about one thousand and seventy-five feet above the main valley of the Sacramento at Oroville.

These mines have been worked for several years, and very profitably, with the scanty supply of water that could be collected during the rainy season. This supply lasting only about thirty days in the year. The industrious and hardy proprietors of these claims saw that the only obstacle that lay between them and large fortunes was a sufficient supply of water, and with this knowledge, and faith in proper engineering skill, they applied to Mr. Watson for his professional aid as early as eighteen hundred and fifty-eight. After a careful survey, he decided that the project was entirely practicable, and could be successfully carried out at a cost that would afford a large return on the estimated outlay. But capitalists viewed the project, and its means of accomplishment, as too chimerical, and declined the solicited aid. The confident

miners, disappointed but not disheartened, kept steadily at work, confident that time would bring about a full realization of their plans and hopes. In eighteen hundred and sixty-nine these mines were capitalized at six hundred thousand dollars. Work was commenced in May, eighteen hundred and seventy, and brought to a perfectly successful conclusion on the last day of the year. The extraordinary wealth of these auriferous beds, as well as many others in that State, may be better comprehended when we are assured by Mr. Watson that the entire outlay on this work will be repaid, from the profits of the mines, by the first of July, eighteen hundred and seventy-one.

These mines are situated on a table of land on the east side of, and one thousand and seventy-three feet above, the main valley of the Sacramento. This elevation is separated on the north from a spur of the Sierra Nevadas by a cañon nearly one thousand feet deep, in the bottom of which flows the West Branch, a tributary of the Feather river. Coming from the north, the Feather river passes on the east side, and sweeps around the south end of the mountain, at the bottom of a deep gulf. This spur of mountain thus stands over a thousand feet above the valley and streams in the vicinity.

The plan devised by Mr. Watson was to take water from the Feather river at an elevation, in the Sierra Nevadas, sufficiently high to secure a flow to the mines; about fourteen miles up the west side of the Feather river he constructed a dam and reservoir of a capacity of seven hundred and eighty-eight million four hundred thousand cubic feet. In order to convey the water to the mines,

the West Branch was to be crossed. From the reservoir to the tank on the north side of the West Branch he conveyed the water in an open canal of a cross section of fifteen feet, and with a grade of twelve feet per mile. From the tank mentioned above, the water is conveyed in iron pipes down the declivity nine hundred and seventeen feet, and across the stream on a bridge constructed for the purpose, and up to the grade line of the canal, and the tank or reservoir on the opposite side. This iron tube is twelve thousand three hundred and forty-five feet in length, and thirty inches in diameter. From this lower reservoir it is conveyed by smaller pipes to the various parts of the mine.

The main tube is constructed of wrought iron, of varying thickness, and in lengths of twenty-three feet, the joints being riveted on the ground with hot rivets. This tube is laid in a trench cut entirely through solid rock, five feet deep, and carefully covered with earth.

The course of the tube forms an inverted siphon ; the pipe, previous to being laid, is steeped in a bath composed of equal parts of asphaltum and coal-tar, kept at boiling heat until the surface and seams are thoroughly coated.

This process was adopted in the preparation of the pipes for the water supply of San Francisco, and after ten years' use they are found to be as perfect as when laid down.

A calculation shows the pressure at the bottom section of the pipe to be very great, amounting to three hundred and ninety-seven pounds per square inch, and the capacity of delivery, when under full head, is forty cubic feet per second.

The thickness of iron at nine hundred feet depth, is three-eighths of an inch ; at eight hundred and forty-five feet, five-sixteenths ; at six hundred, one-quarter ; at four hundred and twenty-five, three-sixteenths ; at three hundred and fifty feet, number ten wire gauge ; at three hundred feet number eleven ; at two hundred and seventy-five feet, number twelve ; and at one hundred and fifty and upwards, number fourteen.

To provide for the escape of air and over-pressure that might enter the tube, a "stand-pipe" is erected fifty feet from the inlet ; there are also, for the same purpose, valves, seven in number, placed at various points along the tops of the pipes ; and three "blow off" pipes, one at each depression of the tube.

Though no new principle in hydraulics has been employed in this work, yet the magnitude of the undertaking has no precedent in civil engineering, and establishes the feasibility of extensive water supply, economically, and in a manner heretofore considered impracticable.

Mr. Watson is still in middle life, and, with his professional attainments and past experience, has every prospect of accomplishing works of still greater magnitude and usefulness. It is difficult to form a proper estimate of the influence of the accomplished works of modern engineering, or the progress of future undertakings. It is of the latent kind, and exercises its power in a silent way, but with a progressive tendency.

JOHN A. ROEBLING,

CIVIL ENGINEER.

THE name of John A. Roebling will always take high rank among the Engineers of America. He was one of many of our foreign-born citizens who have, by their genius and learning, adorned and reflected honor on the country of their adoption. He was a man of whom the engineering profession may justly be proud. His name, with eminent fitness, may take a conspicuous place with the most honorable and zealous in the work of internal improvement and human progress.

The life of Roebling was one of study and labor—a life too soon terminated. He died just after entering upon the development of one of the grandest conceptions of his professional career. But were men's lives measured by what they accomplish, by the good they have done, he lived more than most men who see a greater number of years.

John A. Roebling was born on the twelfth of June, eighteen hundred and six, in the city of Mulhausen, Prussia. After the usual academical course he was sent to the Royal Polytechnic School in Berlin to complete his education as a Civil Engineer. His scholastic career was

marked by an unusually brilliant progress in the study of his profession, and at its close he received the highest honors of his class. This institution being under the patronage of the Government, the State claimed his services for three years, and he was sent to superintend the public works then in progress in Westphalia.

After honorably fulfilling his duty to his royal patron he turned his face toward the New World, and settled, in eighteen hundred and thirty-one, on a tract of land near Pittsburg, Pennsylvania, at that time almost the frontier region of the West. For several years he devoted himself to the improvement of a tract of new land, and the building up of a town. The life of a farmer afforded him so little opportunity for the practice of the art to which he had given so much study, soon became tiresome, and he sought an opportunity for the exercise of his skill in a sphere of action that would better satisfy his professional ambition.

The time thus spent, however, was not wholly lost to his profession. He occupied his leisure in reviewing his former studies, critically investigating the most abstruse principles of mechanics and engineering, and familiarizing himself with the language and public works of his adopted country.

About this time extensive canal and slack-water improvements were in progress. He sought and obtained his first situation as Assistant Engineer on the slack-water navigation of the Beaver river, a tributary of the Ohio. On the close of this engagement he was employed in the same capacity on the Sandy and Beaver Canal, a work intended

to connect the waters of Lake Erie with the Ohio river. From the want of means, and the opposing influence of the rising era of railroads, this work was never completed. Afterwards he was employed on the upper portion of the Alleghany river, in the construction of a feeder for the Pennsylvania Canal. On the completion of this work, he entered the employment of the State of Pennsylvania, and was engaged for three years in the survey of three routes for a railroad across the Alleghany mountains, from Harrisburgh to Pittsburgh. The Pennsylvania Central Railroad Company afterwards constructed the main line of its railroad on the route located by Mr. Roebling.

A short respite from public employment was devoted to the establishment of the manufacture of wire rope, for which purpose he devised new and improved machinery. This was the first attempt in its manufacture in this country, and proved, and has continued to be, a complete success, although much opposition was at first made to its use.

In this manufacture he gained the necessary experience of the nature and qualities of wire, and the practical application and handling of this material, which gave him the confidence to introduce wire ropes into the construction of the first suspension aqueduct in the United States.

In eighteen hundred and forty-four the wooden aqueduct of the Pennsylvania Canal across the Alleghany river, had become so unsafe as to render its removal and the erection of a new structure on the old piers necessary. The time for this change of structure was limited to nine months, including the winter season of eighteen hundred

and forty-four and five. The work was let by contract to the lowest bidder, and was carried to a successful completion by Mr. Roebling within the time specified, and opened to commerce in May, eighteen hundred and forty-five.

This aqueduct comprised seven spans of one hundred and sixty-two feet each, consisting of a wooden trunk to hold the water, and supported by a continuous wire cable on each side, of seven inches in diameter.

A rigorous winter and rapid river current added greatly to the difficulties to be overcome. The novelty of the method of construction, the unavoidable imperfections of untried machinery, employed for the first time in making a large cable on the spot it was to occupy permanently, were no light obstacles to be surmounted. One satisfactory phase, however, in the history of the work, and, indeed, of a subsequent one also, was the practical refutation its success afforded to the numerous attacks of the engineering profession of that day, which derided, in no measured terms, the project of a suspension aqueduct ; its downfall, as soon as the water should be let into it, was predicted by many who were considered eminent in the profession.

Following the building of this aqueduct came the erection of the Monongahela Suspension Bridge, at Pittsburgh, on the piers of the old wooden bridge destroyed by the great fire of eighteen hundred and forty-four, and connects that city with the borough of Sligo, and consists of eight spans of one hundred and eighty-eight feet each, supported by two four and one-half inch cables, which in this

instance were constructed on the bank of the river, separately for each span, and afterwards hoisted in place from flat boats. In this bridge the pendulum principle was applied, to counterbalance adjoining spans under the action of unequal loads.

In eighteen hundred and forty-eight, Mr. Roebling undertook the construction of four suspension aqueducts on the line of the Delaware and Hudson Canal, connecting the anthracite coal regions of Pennsylvania with the tide water of the Hudson river at Rondout. They were all completed within two years, and were of the following dimensions: Lackawaxen aqueduct, two spans of one hundred and fifteen feet each, and two seven-inch cables; Delaware aqueduct, four spans of one hundred and thirty-four feet each, two eight-inch cables; High Falls aqueduct, one span of one hundred and forty-five feet, and two eight and one-half inch cables; Neversink, one span of one hundred and seventy feet, and two nine and one-half inch cables. These are all essentially permanent works, as the wood-work of the trunks only require occasional renewal. During this period Mr. Roebling removed from Western Pennsylvania, and established his works for the manufacture of wire rope, and residence at Trenton, New Jersey.

Suspension bridges was a favorite branch of engineering with him, and was the theme of his graduating thesis. The construction of bridges on the suspension or catenary plan was nothing new, as suspended chain bridges had been in use for many years, both in this country and in Europe. But chains were found not to give equal stiffness

and stability to the structure for a passing load or the force of high winds. A brief description here of a chain bridge built many years ago by John Templeman, as Engineer, across the Merrimac river, three miles below Newburyport, Massachusetts, may be found interesting. The span was two hundred and forty-four feet, and width thirty feet, with two roadways of fifteen feet each. The abutments were of masonry, forty-seven feet long and thirty-seven feet high, upon which supporting towers were erected. Ten chains, three at each outer edge of the bridge and four in the centre, were made to bear, with perfect safety, five hundred tons.

The Potomac Bridge, near Washington, had spans of one hundred and thirty feet, the Cumberland Bridge in Maryland the same ; the Brandywine Bridge was built with one hundred and forty-five feet span ; the chain bridge across the Lehigh, near Northampton, Pennsylvania, was four hundred and seventy-five feet long, in four spans. Others of less importance were erected in different parts of the country.

The first wire bridge, an American invention, was erected over the Schuylkill river. It had a span of four hundred and eight feet.

In eighteen hundred and forty-six his attention was invited by the author, to the erection of a railroad suspension bridge across the Niagara river below the Falls, who desired the opinion of Mr. Roebling as to the practicability of the project. Under date of January seventh, eighteen hundred and forty-seven, Mr. Roebling replied :

“ I have bestowed some time upon this subject since

the receipt of your letter, and have matured plans and working details. Although the question of applying the principle of suspension to railroad bridges has been disposed of in the negative by Mr. Robert Stephenson, when discussing the plan of the Britannia Bridge over the Menai, on the Chester and Holyhead Railway, I am bold enough to say that this celebrated Engineer has not at all succeeded in the solution of this problem. That a suspension bridge can be built to answer for a railroad, is proven by the Monongahela Bridge, which is only intended for common travel, but with some additional expense could be made stiff enough (it is strong enough) for railroad trains at a moderate rate of speed. Castings of ten tons weight, suspended to two pairs of large timber wheels, have lately been hauled over this bridge ; the six-horse coal trains which pass over it hourly weigh seven tons.

"It cannot be questioned that wire cables, when well made, offer the safest and most economical means for the support of heavy weights. Any span within fifteen hundred feet, with the usual deflection, can be made perfectly safe for the support of railroad trains as well as common travel.

"The greater the weight to be supported, the stronger the cables must be, and as this is a matter of unerring calculation, there need be no difficulty on the score of strength. The only question which presents itself is : can a suspension bridge be made stiff enough, as not to yield and bend under the weight of a railroad train when unequally distributed over it ; and can the great vibrations which result from the rapid motion of such trains and

which prove so destructive to common bridges, be avoided and counteracted?

"I answer this question in the affirmative, and maintain that wire cable bridges, properly constructed, will be found hereafter the most durable and cheapest railroad bridges for spans over one hundred feet.

"There is not one good suspension bridge in Great Britain, nor will they ever succeed as long as they remain attached to their chains and present mode of superstructure.

"The larger the span, the stiffer it can be made, on account of its great weight, which is necessary to insure stability. To obtain the greatest degree of stiffness, all the timber applied, should, as much as possible, be disposed in the direction of the floors; truss frames, when made, are useful, but need not be applied to a great extent. To counteract the pliability of a cable, stays must be applied, by which a number of points, which must necessarily correspond with the knots of vibration, are rendered stationary, and so that the stays and cables act in concert in supporting the bridge. * * * * *

"The locality of the Niagara Bridge offers the very best opportunity for the application of a system of stays, which will insure all the stiffness requisite for the passage of railroad trains at a rapid rate. The plan I have devised for the structure will, I have no doubt, convince you at the first inspection that the rigidity of the structure will be ample. The strength of the cables I have based upon the following calculations:

"Total weight of locomotive and train, two hundred

and forty-five tons, the vertical impact of which, when moving at a speed of about twenty miles per hour, will not be less than four hundred tons; to this we have to add the weight of the structure itself, amounting to over six hundred tons, and the weight of a number of teams which may happen to be on the bridge at the same time a train is passing; also for a foot of snow which may happen to fall during a single night. By adding these items of weight, and allowing *no less than five times* the strength of wire which would barely support the tension resulting from these pressures, for the strength of the cables and stays, we will be found altogether on the safe side; and by securing the cables against all chances of rusting, and preserving all the timber parts of the structure, we will be able to put up a bridge which will last for ages, and offer at all times a safe passage for railroad trains as well as common travel."

Mr. Roebling manifested his confidence in the success of the enterprise by an offer to construct the bridge on the foregoing principles, with two tracks for common travel, two footwalks, and one railroad track, within fifteen months, for the sum of one hundred and eighty thousand dollars, subscribe twenty thousand dollars to the capital stock, and give security for the complete success of the work in all its parts.

For this, the first bridge erected over the Niagara, Colonel Ellet was the successful competitor. When it was afterwards determined to replace this structure by a railway bridge, Mr. Roebling's plans were accepted, and he was appointed Chief Engineer of the work. He

always declined to furnish plans for an important structure of this kind that could not be erected under his personal supervision, neither would he undertake work upon plans made by others. He was not an imitator ; all his great constructions were essentially different, and planned to meet the special features of the location, and when he had once decided upon his plan, he was sanguine of its success, and his whole energies were directed to its accomplishment.

His own eye must examine every portion of the structure as it was put together, and nothing beyond the manual labor was intrusted to others.

In eighteen hundred and fifty-one, he commenced operation on the Niagara River Bridge, and for four years the work continued without interruption, even during the coldest of Canadian winters. In eighteen hundred and fifty-four the lower floor was opened to roadway travel, and in March, eighteen hundred and fifty-five the first locomotive and train of railway cars crossed a wire suspension bridge, and to this day no interruption in its use has occurred.

It is perhaps unnecessary here to enter upon a full description of the details of the structure; it may be sufficient to give its main features that its magnitude may be understood. Length of span, eight hundred and twenty-five feet, height of railway track above the water, two hundred and fifty feet. The cables are four in number, each containing three thousand five hundred and sixty-nine number nine wires. It has two floors or platforms. The lower one designed for roadway use, and

the upper one for a railway track. The floors are supported by struts and diagonal tension rods from the cables, so that the structure forms a continuous hollow girder stiff enough to sustain the movement of a railroad train.

Heretofore it had been the practice to lay each wire singly, one by one, until the number required for the cable was placed, and to hold them together by bands or coils of wire, placed at short distances apart. Mr. Roebling invented and used for this bridge, a machine for winding the cables, with small wire from end to end, in a manner that protects them from the action of the atmosphere and binds them, in a degree, into a solid mass.

Simultaneous with the progress of the Niagara Bridge, another railway suspension bridge was commenced by Mr. Roebling over the Kentucky river on the projected line of the Lexington and Southern Kentucky Railroad. The gorge to be crossed here was both wider and deeper than that at Niagara, requiring a span of twelve hundred and twenty-four feet. The anchorages were laid and the stone towers erected, and most of the cable wire and other material for the superstructure delivered at the site, when, the Company becoming financially embarrassed, the work was suspended and has not since been resumed. In this bridge no carriage way was designed, and the plan of the structure was essentially different from that of the Niagara Bridge.

In the fall of eighteen hundred and fifty-six he laid the anchorages and foundations for the towers of the Cincinnati and Covington Suspension Bridge. Mr. Roebling devised a plan for this bridge in eighteen hundred and

forty-six, quite a different one, however, from the one he has since built. His first plan contemplated a tower in the centre of the river, and two spans of seven hundred and ninety feet each. The progress of this bridge was interrupted for the want of sufficient means, and the outbreak of the rebellion, until eighteen hundred and sixty-three, when the work was recommenced, and the bridge completed in eighteen hundred and sixty-seven.

* "At the lowest stage of water the Ohio river, between Cincinnati and Covington, has a width of about one thousand feet. By the charter of the Company the position of the towers was fixed at low-water mark, so that the middle span should present an opening of not less than one thousand feet in the clear. In the spring of the year eighteen hundred and thirty-two the river rose sixty-two feet above low water. At this stage, the width of waterway is over two thousand feet. With the exception of the towers, the whole waterway between the two cities is left unobstructed, a width of sixteen hundred and nineteen feet. The two small spans left open between the abutments and towers are each two hundred and eighty-one feet, from face, to centre of towers. In an engineering point of view, this division of spans is not the most economical. The cheapest arrangement would have been one centre span of eight hundred feet, and two half spans of four hundred feet each. But that plan had been forestalled by previous legislation. One of the early charters decreed one single span of fourteen hundred feet in the clear. But this very great and expensive span was afterwards allowed

* Report of Covington and Cincinnati Bridge, J. A. Roebling, 1867.

to be reduced to one thousand feet, and with this amendment the foundations were commenced in eighteen hundred and fifty-six.

“ Owing to the persistent opposition of property-owners, steamboat and ferry interests, the clear elevation of the floor above low-water mark, in the centre of the river span, had been fixed at one hundred and twenty-two feet. By a later enactment, this height was reduced to one hundred feet. As the bridge stands now, its elevation is one hundred and three feet in the clear above low-water mark, at a medium temperature of sixty degrees, rising one foot by extreme cold, and sinking one foot below this mark in extreme heat. The greatest ascent is only five feet in one hundred, at the Cincinnati approach, and this diminishes as the suspended floor is reached.

“ The floor of the bridge is formed of a strong wrought-iron frame, overlaid with several thicknesses of plank, and suspended to the two-wire cables by means of suspenders attached every five feet, arranged between roadway and footpaths ; the latter seven feet wide, and are protected by iron railings towards the river. The roadway is twenty feet wide, forming two tracks of four lines of iron trams, on which the wheels run, each tram being fourteen inches wide, to accommodate all kinds of gauges. The whole width of the floor between the outside railings is thirty-six feet. No stays or other obstructions are put up below the floor, such as may be seen under the Niagara Bridge. No such means to prevent the floor from rising was used in this work ; its security and stability are provided for by other appliances. The rock underneath the Niagara

Bridge afforded a very cheap mode of anchoring ; it would have been a great oversight on my part not to avail myself of under-floor stays in such a favorable locality. But in the Ohio river no such appendages were admissible.

“ The general plan which I have always pursued in my works insures, by the heavy contraction of the cables in the centre of the span, great lateral stability at this point. The larger and heavier the span, the greater will be its comparative stability at the centre. Vertical stability in the centre is also insured in large spans by the weight of the structure. But not so between the centre and the towers. In consequence of the equilibrating tendency of the two opposite halves, vertical oscillations occur easier, and the great length of suspenders, acting like pendulums, promotes lateral displacements. These tendencies have to be met, and are thoroughly overcome in the Ohio bridge by an effective system of stays. The very careless manner in which stays have been attempted heretofore is a violation of the principle involved. Their arrangement in this bridge not only insures their own freedom from oscillation, but renders them fully effective by the uninterrupted preservation of their lines.

“ Aside from simply stiffening the floor, the stays are rendering another and very important service ; they effectually insure equilibrium between the main and half spans. Without stays the balance between adjoining spans would sometimes be greatly disturbed by unequal loads. The large crowds of many thousands of people which frequently cover the floor from one end to the other, are occasionally very unevenly distributed, but

they have never produced the slightest injurious effect upon the statical condition of this work.

"Great doubts are yet entertained by many engineers, particularly in Europe, in regard to the fitness and safety of suspension bridges for railway purposes. By an additional expenditure of fifty thousand dollars, and a railroad track laid down in the centre of the floor, the Ohio bridge could have been made serviceable for the passage of locomotives and trains at the highest speed. Let any person who doubts this, observe the very slight tremor which is produced on this bridge by a long line of heavily loaded teams, frequently ten in a row, and he will readily understand that but a small addition of rigidity is wanted in order to pass railroad trains."



SUSPENSION BRIDGE OVER THE RIVER OHIO AT CINCINNATI.

The principal dimensions of this bridge are: Main span, from centre to centre of towers, one thousand and fifty-seven feet. Side spans, from abutment to centre of tower, two hundred and eighty-one feet. Total length between abutments, one thousand six hundred and nineteen feet. Elevation of floor above low water at tower,

ninety-one feet. Elevation of floor above low water at centre, one hundred and three feet. Length of Cincinnati approach from Front street to abutment, three hundred and forty-one feet. Length of Covington approach from Second street to abutment, two hundred and ninety-two feet. Total length, including approaches, two thousand two hundred and fifty-two feet. Number of cables, two, each twelve and one-third inches in diameter. Number nine wires, in each cable, five thousand two hundred. Ultimate strength of one cable, four thousand two hundred and twelve tons. Weight of main span between towers, one thousand five hundred tons. Number of stays in main span, seventy-six—strength of each, ninety tons. Weight of main span between towers, as far as supported by cables, one thousand three hundred tons. Deflection of cables in main span, eighty-nine feet. Permanent tension to strength, one-eighth. Ordinary working tension to strength, one-seventh. Maximum tension to strength, one-sixth. Section of each anchor chain in square inches, one hundred and ninety. Area of each foundation in square feet, eight thousand two hundred and fifty. Cubic contents of masonry of each tower, four hundred thousand feet.

During the delay of the Cincinnati Bridge, arrangements were made to proceed with the erection of still another suspension bridge at Pittsburgh, to take the place of the old wooden Alleghany Bridge, built in eighteen hundred and eighteen, and then no longer safe. The removal of the old structure and construction of the new permanent work, including the building of the three

new piers and two anchorages, required three years from eighteen hundred and fifty-eight, to eighteen hundred and sixty inclusive. The total length of this bridge is one thousand and thirty feet, divided into two spans of three hundred and forty-four feet each, and two side spans of one hundred and seventy-one feet each. The floor has a width of forty feet, including two sidewalks, ten feet wide. The frame work of the superstructure is composed essentially of iron girders, with a flooring of wood. Ornamental open towers of cast-iron support the cables, which are four in number, two of seven inches in diameter, attached to the floor between the sidewalks and carriage-way, and two of four inches in diameter, attached to the ends of the floor beams; in addition to the cables, there is an effective system of stays.

Mr. Roebling's last great work was the design and plan of the East River Bridge, connecting the cities of New York and Brooklyn, which, when completed, will be one of the grandest of engineering triumphs. Though he lived only to see the work begun, and its prospects of completion assured, his plans, as was his habit, were so carefully and perfectly matured, that his death caused no suspension or delay in the work.*

The following is taken from his report to the President and Directors, made in eighteen hundred and sixty-seven: "The central span will cross the river from pier line to pier line, without impeding the navigation, in one single span of one thousand six hundred feet from centre to

* The bridge is now being constructed under the charge of his son, Col. W. A. Roebling, who possesses much of his father's ability.

centre of tower. From each tower towards the land side, half spans will be supported by the land cables, nine hundred and forty feet long each, measuring from the centre of tower to the face of anchor wall. From the anchor wall on the New York side, a distance remains of one thousand three hundred and thirty-seven feet to Chatham street. The distance from the anchor wall to the Brooklyn terminus measures eight hundred and thirty-seven feet.

"The greater length of the bridge, therefore, forms a suspension bridge proper. For a better understanding of the subject, those portions between the anchor walls and the termini I shall call approaches. These approaches will be supported by iron girders and trusses, and these will rest at short intervals upon small piers of masonry or iron columns, located within those blocks of buildings which will be crossed and occupied. These pillars will form parts of wall, needed for the division of the occupied grounds into stores, dwellings, or offices. In every case the bridge floor will be constructed perfectly fire and water proof, so as to serve as a roof to the blocks of houses and stores underneath. The streets will be crossed by iron girders at such elevations as to leave them unobstructed. This can be accomplished even in the crossing of North William street in New York, so that on this side no necessity will arise for the vacation of any one street. In the crossing of Franklin Square both girders and trusses will be employed. The general arrangement of this part of the structure will become clearer by an inspection of the accompanying plans."

"From the anchorage towards the river the bridge floor is suspended to the cables, and, therefore, needs no support. The elevation will be so high that the roofs of the buildings underneath will be cleared. This elevation, at the anchorage, will be eighty-five feet eight inches above high tide, ascending towards the river at the rate of three feet five inches in each hundred feet. The iron framing, which forms the bridge floor, is eighty feet wide. This width is divided in five spaces, marked by six lines of iron trusses. The two outside spaces are fifteen feet wide in the clear between the chords, and fifteen feet five inches between the posts, and form roadways for all kinds of common travel. Iron tramways are laid down eighteen inches wide for the wheels to run on, the same arrangement as on the Cincinnati Bridge, leaving a width of four feet eight and one-half inches in the clear for the horses to walk on. The remaining six feet serve as a sidewalk for pedestrians. The next two spaces are thirteen feet wide each, and are to be provided with steel rails for the running of two passenger trains of cars, back and forward alternately. These trains will be attached to endless wire rope, which is to be propelled by a stationary engine, located on the Brooklyn side, underneath the floor.

"The cables of the East River Bridge will have a deflection of one hundred and twenty-eight feet, which is two twenty-fifths of the span, and the tension which is produced thereby will be about one and two-thirds of the weight of the wire. The weight of superstructure of the central span, as far as supported by the

cables and stays, and including the weight of four steel cables, is equal to three thousand four hundred and eighty-three tons. The maximum transitory weight which can at any one time come on the bridge, by crowds of people on the road and footways, and the railway trains fully loaded, will be one thousand two hundred and seventy tons, making an aggregate of four thousand seven hundred and fifty-three tons.

"To guard against vertical and horizontal oscillations, and to insure that degree of stiffness in the flooring, which is absolutely necessary to meet the effects of violent gales in such an exposed situation, I have provided six lines of iron trusses, which run the whole length of the suspended floor, from anchor wall to anchor wall. The iron floor beams, which are spaced in pairs, seven feet and one-half apart, intersect longitudinal trusses at right angles, and are riveted to the middle cords and to the upright posts. The height of each truss is twelve feet, the floor being laid above the centre, so that the upper part of the truss frames answers for protection, as well as division, in place of railings.

"Those parts of the longitudinal trusses which extend below the floor beams, afford an excellent means for *lateral* trussing and bracing, as will be readily understood by an inspection of the drawings. A most effective framing is thus obtained, which will be found to possess ample stiffness even in the greatest emergency.

"The superstructure will be firmly anchored upon the masonry of the towers and of the anchor walls. Ample provision will also be made for horizontal bracing under-

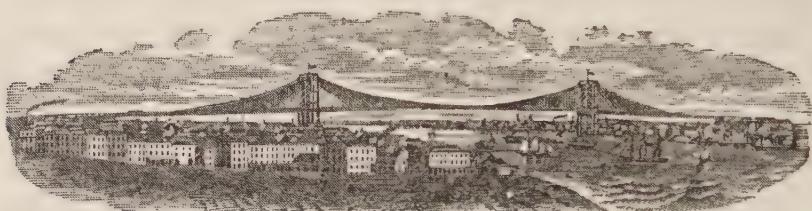
neath the floor. The great massiveness of the towers and of the anchor walls will furnish a sure anchorage for horizontal bracing.

" A most powerful element of resistance to storms will be found in the great weight and inertia of the cables, and of the whole superstructure. This will be still more increased by the lateral inclination of the cables. Two of these will be suspended outside, and they will incline towards each other. The other two will be supported by the central shafts of the towers, and in their descent will spread apart. The weight of the superstructure, without cables, will be two thousand six hundred and seventy-five tons.

" The great features of the work will be the two towers. The base of each tower, at the water line, measured in the direction of the river, is one hundred and thirty-four feet long, and its extreme width will be fifty-six feet. Below the upper cornice, at the top of the tower, these dimensions are reduced to one hundred and twenty feet by forty feet. This reduction is not effected by a gradual drawing in or sloping, but by sloped offsets at intervals, which leave the intermediate portions of the masonry plumb face. The elevation of the floor is one hundred and eighteen feet above high water ; the height of the roofing above the floor is one hundred and fifty feet, making a total height of two hundred and sixty-eight feet from high water to top or roof, not including the balustrade and ornamental blocks. This large body does not form one solid mass, but is built hollow. Starting with the masonry three feet below low water, the cubical quantity in the two towers

will be sixty-two thousand eight hundred and twenty-four cubic yards, of twenty-seven cubic feet each.

“The proposed bridge over the East River will cost from six to seven millions of dollars.”



The New York and Brooklyn Suspension Bridge, in course of construction.

That Mr. Roebling had a full appreciation of the magnitude and importance of the undertaking may be inferred from the closing sentence of his report :

“The contemplated work, when constructed in accordance with my designs, will not only be the greatest bridge in existence, but it will be the great engineering work of this Continent and of the age. Its most conspicuous features—the great towers—will serve as landmarks to the adjoining cities, and they will be entitled to be ranked as national monuments. As a great work of art, and as a successful specimen of advanced bridge engineering, this structure will forever testify to the energy, enterprise, and wealth of that community which shall secure its erection.”

Mr. Roebling’s reasoning was always clear, simple, and explicit, and sustained by philosophical and scientific facts. He took nothing for granted. His arguments were drawn from his store of scientific knowledge, with a mathematical accuracy and fitness that carried with them

a conviction of truth. He was impatient at captious opposition to his projects, but always courted a discussion of his plans by those who brought sound theoretical or practical opposition to his views. In a report made by him for a suspension bridge at Cincinnati, as early as eighteen hundred and forty-six, and to which there was much opposition from those interested in river navigation, he says in effect, I have no fears of those who *honestly* believe the bridge to be injurious to the navigation; the opposition of cavillers I most dread.

Several years ago Mr. Roebling proposed and published a theory of the crank motion, which he supported by argument and illustration.* The proposition attracted the attention of Engineers, and various replies and elucidations were given by different writers. In vol. v., page 36 of the *Journal*, Edwin F. Johnson, the eminent Civil Engineer, over the *nom de plume* of "Fulton," offered a solution of the question, in which he demonstrated the error of the proposition. Mr. Roebling, in the most frank and manly manner, replied that the solution of the question of the crank offered by "Fulton" had led him "to consider the subject more attentively than he had done," expressing himself "greatly indebted to the calm and methodical reasoning of 'Fulton' for the conclusions to which he had at last arrived." Although these gentlemen never met each other, a friendly correspondence was maintained between them for many years, each enjoying a high opinion of the other's skill and professional knowledge.

* *Railroad Journal and Mechanics' Magazine*, vol. iv., 2d series, p. 161.

His conclusions were always practical, and adapted to the circumstances of a given case. In the report on the Cincinnati Bridge, before referred to, in meeting the question of the height of the chimneys of the river steamboats, he says: "For a series of years the boats have increased the height of their chimneys; it is inferred from this that no one could tell where they would stop. If it was established that the growth of chimneys was in a direct proportion to the power and capacity of a boat, then the previous observation would be entitled to serious attention. But, fortunately, the very reverse will be found to be the fact in the future; paradoxical as this may be, it is nevertheless true, and will be assented to by those who have made themselves acquainted with the principles of the steam engine and steam generators.

"The ostensible object of high chimneys on board of steamers is to create more draft. Now, it is fully established and generally known that economy in fuel is inversely as the rapidity of combustion. And, on the other hand, the escape of lost heat and unconsumed fuel up the chimneys is in direct proportion to the draft. These points are better understood on our Eastern waters, and in ocean navigation, where economy of fuel is a greater desideratum than here in the West. The question of an increased speed is there not solved by simply raising the chimneys, and increasing the draft, but by other means, a little more creditable to science. In future, the power and value of a boat will be estimated, not by the height of their chimneys, as is now the case, but by their lowness. Low chimneys on a powerful boat will be the best proof

of a superior arrangement for the generation of steam. But as there are a number of boats still running which carry high chimneys, and as this fashion is likely to continue for some time yet, we shall be obliged to adopt, in the construction of the proposed work, an elevation unnecessarily high."

One of his strongest moral traits was his power of will, not a will that was stubborn, but a certain spirit, tenacity of purpose, and confident reliance upon self, that was free of conceit; an instinctive faith in the resources of his art that no force of circumstance could divert him from carrying into effect a project once matured in his mind. His skill as an Engineer was not surpassed by his exact probity. He held it "to be the duty of an Engineer, when charged with the designs of public works, to report previous to their execution fairly, accurately, and candidly," and that "honesty of design and execution, next to knowledge and experience, most surely guarantees professional reputation." Before entering upon any important work, he always demonstrated to the most minute detail its practicability to his own mind at least, by scientific experiment and critical test; and when his own judgment was assured, no opposition, sarcasm, or pretended experience, could divert him from consummating his designs, and in his own way.

His brain was fertile in expedients to meet and overcome any incidental impediment that might arise in the course of construction of any work.

In his charities he was exceedingly liberal, and what he bestowed was given without ostentation. A plea for aid

from the poor and humble, although his time was precious, always received attention, and a share of his bounty. His social and domestic relations were most agreeable. In conversation he was earnest, instructive, and exceedingly entertaining. His sympathies for the working man were large, and he lost no opportunity to promote harmony and good feeling between the employer and the employed.

Besides his reports upon the various works upon which he was engaged, he left but one publication, entitled, "Long and Short Span Bridges," * a very valuable work, profusely illustrated by elaborate drawings.

"He needs no eulogy other than the simple record of his life, and no monument can be reared that is not entirely insignificant in comparison with his works."

He died on the twenty-second day of July, eighteen hundred and sixty-nine, from the effects, indirectly, of an injury which he had received three weeks previously at Brooklyn, when his foot was crushed while directing the commencement of the work on the East River Bridge. His funeral was largely attended by public and private citizens at Trenton, New Jersey, where his remains lie buried.

* New York : D. Van Nostrand, eighteen hundred and sixty-nine.

APPENDIX A.

Extract from a description of the Union Canal, written in 1830, by W. MILNOR ROBERTS, Resident Engineer.

THE Union Canal begins two miles below Reading, and extends to Middletown, nine miles below Harrisburgh, connecting the Schuylkill with the Susquehanna river. Its length is seventy-nine miles, exclusive of a navigable feeder on the Swatara. The summit level passes through a tunnel eighteen feet wide, fourteen feet high, and seven hundred and thirty-nine feet long. There are two reservoirs for this summit, containing twelve million cubic feet of water; one of them covering eight, and the other twenty-seven acres. There are two steam engines of one hundred horse power each, and three water-wheels for supplying the summit with water, capable of raising to advantage 1,250,000 gallons every twenty-four hours.

There are three dams for supplying the main canal with water—one across the Schuylkill river, and two across the Swatara. The *great dam*, located in a narrow gorge, through which the Swatara passes, and near the northern declivity of the Blue Mountain, is a stupendous structure, and holds in check an immense artificial lake covering about *eight hundred acres*. The crib work measures *two hundred feet across the stream and forty feet in perpendicular height*, composed of timbers of 10 by 12 inches. Those at the base are of white oak, the remainder of white pine, laid at right angles, forming squares six to eight feet from centre to centre, firmly treenailed, filled with stone, and the whole strongly fitted against the mountain on the west end. On the east end is an abutment of stone, laid in hydraulic cement, forty-eight feet high, eight feet above the top of the dam. The dam has a base in the direction of the stream of one hundred and ten feet. The embankment of earth and stone reaches to the east side of the gap, a distance of two hundred and thirty feet;

it is two hundred and sixty feet wide on the base, and sixty feet in width at the outer surface, and fifty feet in height, being ten feet above the dam. There are twelve sluice gates about six feet above the bottom of the dam, each having an opening of two feet square. They are of cast-iron, raised or lowered by means of screws. The sluice gates and machinery are surrounded by a strong framework, connected with the western shore by a light bridge.

APPENDIX B.

FIRST EIGHT-WHEEL LOCOMOTIVE.*

An eight-wheel steam engine, designed by Horatio Allen in eighteen hundred and thirty, was built in eighteen hundred and thirty-two, and put in use on the South Carolina Railroad. Two of these engines were built, each having two four-wheel swivelling trucks. The inner pairs of wheels were larger in diameter, and were driving wheels, with crank axles, connected with the steam-chest, midway between them.

The body was a steam boiler, with furnace in the middle, and a smoke-pipe at each end, and, from its construction, its use was limited to the purpose of a traction engine, and not adapted to move a train of cars. These eight-wheel engines were used on the South Carolina Railroad, and answered the purpose for which they were built. This plan, however, of traction engines did not go into general use ; nevertheless, it was the first application of the swivelling truck to the railroad engines, relying upon the guiding control of the flanges on the wheels, in connection with the propulsive power in the same engine.

The English plan of engine was found not suited to the sharp curves sometimes necessary on American railroads. An English-built engine was for many years used on the Camden and Amboy Railroad, by adding a pair of small pilot wheels, connected to an incline frame, in front ; but this plan very soon gave way to the modern eight-wheel locomotive, substantially as invented by Horatio Allen, having four driving-wheels in the rear, on two parallel axles attached to a rigid frame, and a four-wheel swivelling truck in front,

* Compiled for this volume, from records and proofs in the cases of *Winans vs. Orsamus, Eaton et al.*; *Mathews vs. The Pittsburg, Fort Wayne and Chicago Railroad Company*; and the patents of *Campbell, Eastwick, and Harrison*, by Hon. *Wm. Wheeler Hubbel*, of Philadelphia.

adapted to run equally well on both curved and straight lines of road, and at the highest speed.

The first engine with a single pair of driving-wheels in the rear, on an axle attached to the main frame, with side cylinders, and a four-wheel swivelling truck in front, operating with a free motion, guided, restrained, and controlled only by the flanges on the wheels acting against the rails, and not affected by either cylinder connections or draft couplings, was built by John B. Jervis, of New York, Civil Engineer, in eighteen hundred and thirty-two. This engine had the propulsive power and adhesion entirely independent of the guiding action of the truck, which enabled it to run with ease on a curved or straight track, and was used on the Mohawk and Hudson Railroad ; it had six wheels, and was named the "Experiment." Many engines on this plan were afterwards built, and did good service ; but they were necessarily light, as the whole propulsive effect resulted from the adhesion of a single pair of wheels, and any addition to the weight of the engine, or increase of speed of the train, was attended with rapid destruction of the rails.

In order to distribute the weight more completely, Henry R. Campbell patented, in eighteen hundred and thirty-six the duplication of the driving wheels, and built an experimental engine, which was tried on the Philadelphia, Germantown and Norristown Railroad, but was not purchased by that Company. It was afterwards sent to the Long Island Railroad. Though this locomotive was a step in the way of improvement, it was not a success; there being no means employed to equally distribute the weight between the driving wheels, or to prevent excessive battering of the undulating rails, as the weight of the engine was increased.

For the purpose of equalizing the weight and action of the four driving wheels, an engine named the "Hercules," was in the summer of eighteen hundred and thirty-seven, designed by A. M. Eastwick and Joseph Harrison, Jr., and put in use on the Beaver Meadow Railroad in Pennsylvania. Mr. Eastwick obtained a patent for his improvement. It consisted of a separate frame at the rear, under the main frame, with the two sets of driving wheels attached to this under frame, which was rigid and vibrated vertically. This accommodated itself to undulations, alike on both rails, but not to those in one rail only, which are the most numerous.

Joseph Harrison, Jr., in eighteen hundred and thirty-eight, improved upon Mr. Eastwick's patent by making the pairs of driving wheels on each side of the engine to independently equalize the

weight and shocks, so as to conform to undulations as they occurred on either side of the road.

This engine did not demonstrate much superiority over the Eastwick engine until the equal distribution of the weight and concussion, arising from undulations of the track upon all the wheels, was so accomplished, that at no time should the entire weight or shock of either side be thrown upon any one wheel or pair of wheels. This was effected by Mr. Harrison by applying parallel driving wheel axles directly to pedestals in the main frame, with the addition of a compensating lever between the axle bearings on each side of the engine.

With the equalizing principle of Harrison in the arrangement of the driving wheels came an increased weight of engine, and consequently increased power of traction, with diminished wear upon the rails.

Garrett Eastwick & Co. built the first engine, constructed on this system, for the Beaver Meadow Railroad, immediately after building the "Hercules." They constructed engines upon this plan for several other railroads; and their success became established, and general.

The invention of this arrangement of the driving wheels was accompanied by other incidental inventions and improvements by these ingenious mechanics, and the engines constructed by them accomplished high speed, relieved the destructive wear upon the roadway, and admitted a large increase in the weight, and consequently improvement in tractive power in the engine.

One of these engines, in use on the Philadelphia and Reading Railroad in eighteen hundred and forty-one, particularly attracted the attention of the Russian engineers, Colonel Molnikoff and Colonel Krafts, who were commissioned by the Emperor Nicholas to examine and report upon the various railroads and railroad machinery then in operation in Europe and America.

The result of their examinations was favorable to the American railroad system, and the eight-wheel engine was deemed the best for use in their own country. They consequently made a contract with Eastwick & Harrison by which their works in Philadelphia were discontinued, and they, with Thomas Winans, of Baltimore, removed to, and built up the same system in, Russia. In the mean time engines upon their plans were extensively manufactured and used on the rapidly increasing railroads of this country, in England, and on the Continent.

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